COMPARATIVE PERFORMANCE OF HIGH EFFICIENCY SHIP PROPULSION SYSTEMS FOR DESTROYER HULL TYPES. VOLUME II. APPENDICES

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VOLUME II

APPENDICES

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Final Report
6 December 1974

VOLUME II

APPENDICES

VOLUME II

APPENDICES (Cont'd)

VOLUME II

LIST OF ILLUSTRATIONS

VOLUME II

LIST OF TABLES

APPENDIX A - MATH MODELS

This appendix contains the math models used in computer simulation of the systems.

A.1 TURBINE MATH MODELS

The gas turbines were modeled using the following expression for fuel rate:[1]

$$W_F = \frac{Q_T + W_1 + W_2 S_T}{W_3 - W_4 S_T} \qquad (A1)$$

Where: W_F = Fuel Rate (lb/hr)

Q_T = Turbine Torque (lb - ft)

S_T = Turbine Speed (rpm)

W_1, W_2, W_3 and W_4 are constants characterizing the turbine.

The following constraints were imposed:

$Q_T \leq Q_{MAX}$ Where Q_{MAX} = Max. allowable steady-state torque

$S_T \leq S_{MAX}$ Where S_{MAX} = Max. allowable steady-state rpm

$W_{MIN} \leq W_F \leq W_{MAX}$ Where W_{MIN} = Min. allowable (idle)/fuel rate

W_{MAX} = Max. allowable fuel rate

The turbine power is:

$$P_T = 1.904 \times 10^{-4} S_T Q_T \qquad (A2)$$

Where: P_T = Turbine shaft horsepower

---

(1) Expressions developed by NSRDC, Annapolis.

Specific Fuel Consumption is:

$$SFC = W_F/P_T \text{ (lb/hp - hr)} \tag{A3}$$

The maximum available turbine power occurs at $W_F = W_{MAX}$ and a turbine speed, S_0; at this point:

$$Q_0 = \frac{W_3 W_{MAX} - W_1}{2}$$

$$S_0 = \frac{W_3 W_{MAX} - W_1}{2 (W_4 W_F + W_2)} = \frac{Q_0}{W_4 W_F + W_2}$$

$$P_{MAX} = 1.904 \times 10^{-4} S_0 Q_0$$

$$SFC_{MIN} = W_{MAX}/P_{MAX}$$

In order to compare turbine performance at various operating points, a turbine figure-of-merit was defined as:

$$FOM = SFC_{MIN}/SFC \tag{A4}$$

For any given power, P_T, there will be an optimum Speed, S_{To}, which minimizes the fuel rate (and SFC), given by:

$$S_{To} = \sqrt{(\beta W_4 P_T)^2 + \beta W_3 P_T} - \beta W_4 P_T \tag{A5}$$

$$\text{Where } \beta = \frac{5252}{W_1 W_4 + W_2 W_3}$$

For a given fuel rate, W_F, the maximum power and associated speed and torque may be expressed by:

$$S_{T0} = \rho/2\sigma$$

$$Q_{T0} = \rho/2$$

$$P_{T0} = 1.904 \times 10^{-4}\ \rho^2/4\sigma$$

Where: $\rho = W_3\ W_F - W_1$

$$\sigma = W_4\ W_F + W_2$$

With the fuel rate fixed, power may then be expressed as a function of the speed:

$$\frac{P_T}{P_{T0}} = \left(2 - \frac{S_T}{S_{T0}}\right)\left(\frac{S_T}{S_{T0}}\right);\ W_F \text{ constant.} \qquad \text{(A6)}$$

This behavior is shown in figure A1.

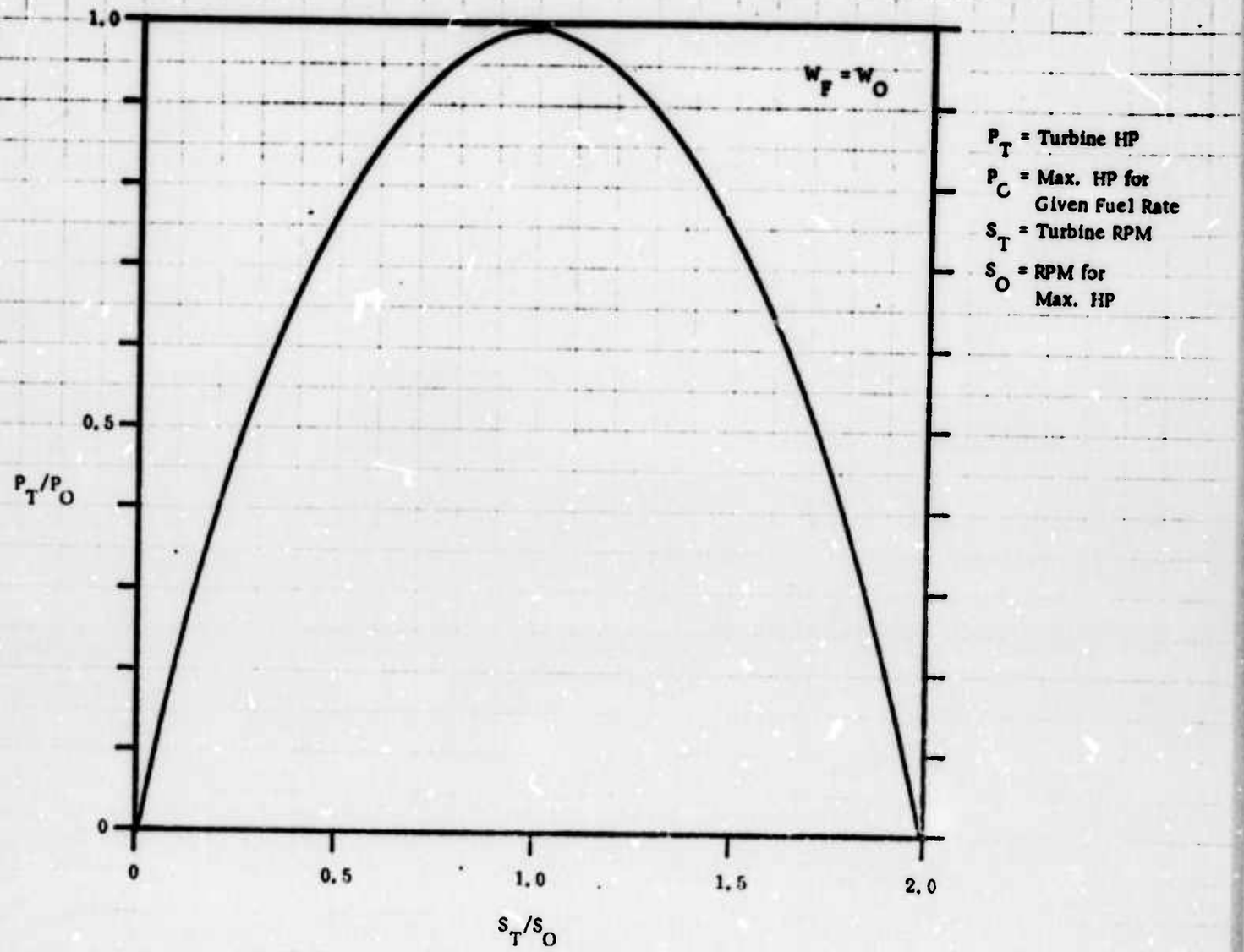


Figure A-1. Power vs. Speed for Fixed Fuel Rate

A.1.1 Main (LM - 2500) Turbine

Constants used for the LM - 2500 turbine were as follows[1]:

$W_1 = 6600$	$W_3 = 9.143$
$W_2 = 1.05$	$W_4 = 1.143 \times 10^{-3}$
$W_{MIN} = 1100$ lb/hr	$W_{MAX} = 8400$ lb/hr
$Q_{MAX} = 60,000$ lb-ft	$S_{MAX} = 3600$ rpm

These values result in optimum operating speeds vs. power and corresponding FOM and fuel rate values, as shown in figure A2. Maximum power is 22,024 hp at 3295 rpm, with an SFC of 0.3814 lb/hp-hr (FOM = 1.0).

A performance map showing power and SFC vs. shaft speed is shown in figure A3. The effect on fuel consumption of operating the turbine at other than the optimum speed, S_{TO} (shown by a dash-dotted line) may be seen on the figure. For example, at 10,000 hp:

Speed	Fuel Rate	SFC	% Increase in Fuel
2000 rpm	5099 lb/hr	0.510	7.1
2840 rpm[2]	4760 lb/hr	0.476	0
3600 rpm	4966 lb/hr	0.497	4.3

(1) Based on NSRDC, Annapolis values developed for superconductive drive system studies; the values used (with the possible exception of W_{MIN}) should not vary significantly for 20,000 hp turbines other than the LM-2500; while the study results for each configuration depend on the specific constants, comparative results between configurations are not highly sensitive to the choice of constants.

(2) Optimum speed.

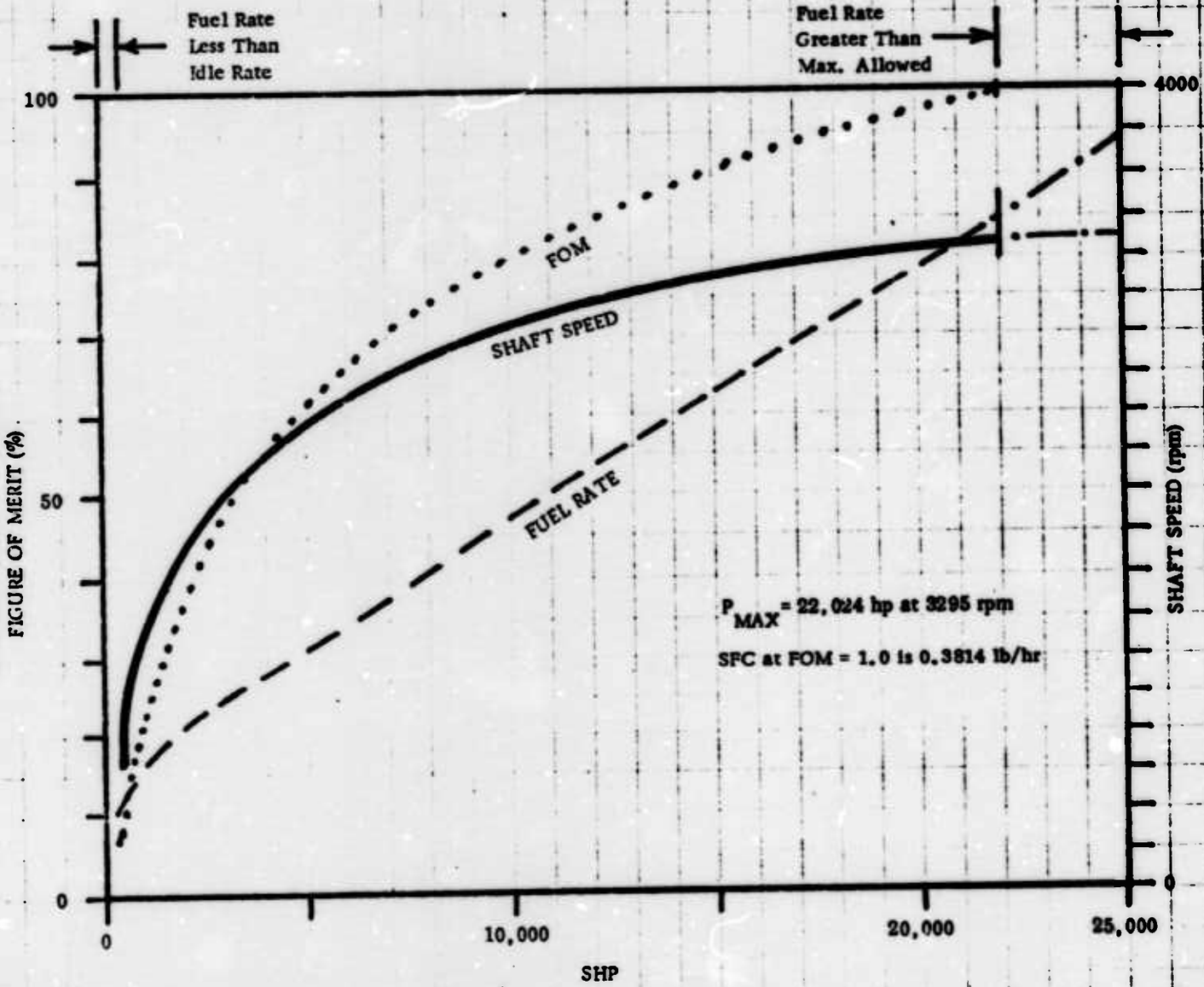


Figure A-2. LM-2500 Turbine Model - Optimum Operating Conditions

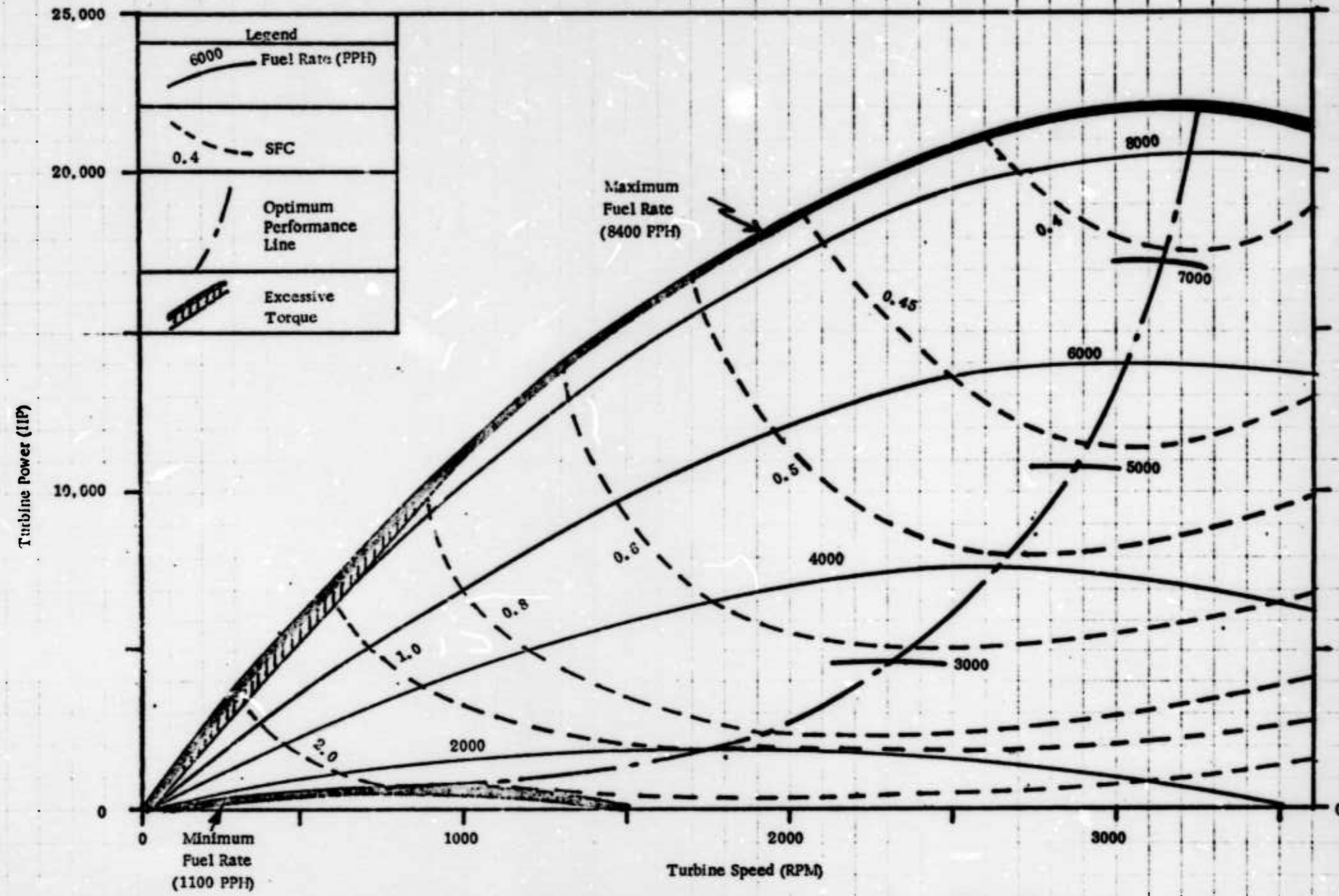


Figure A-3. LM-2500 Turbine Model - Power and SFC Vs. Speed

A.1.2 Cruise (Garrett GTPF990) Turbine

The following constants were used[1]:

$W_1 = 750$	$W_3 = 3.35$
$W_2 = 0.06$	$W_4 = 19 \times 10^{-5}$
$W_{MIN} = 360$ lb/hr	$W_{MAX} = 2700$ lb/hr
$Q_{MAX} = 7500$ lb - ft	$S_{MAX} = 7200$ rpm [2]

Resulting optimum performance points are shown in figure A4, and performance as a function of power and speed are shown in figure A5. Maximum power is 5716 hp at 7200 rpm[3] with an SFC of 0.4724 (FOM = 1.0).

A.1.3 Adjusted FOM

The figure-of-merit expresses the turbine efficiency as a percent of its optimum SFC. The SFC, in turn, may be related to the thermal efficiency of the turbine.

---

(1) Based on NSRDC-Annapolis superconducting propulsion study values (characteristic of 5,000 hp turbines; see footnote[1] on page A-5).

(2) 7200 rpm is the power assembly speed; the standard Navy version has a built-in 2-1 gear reduction to 3600 rpm. Ref: Gas Turbine World, September 1974, p. 12.

(3) Performance is limited by the 7200 rpm shaft speed limit; if there were no speed limitation, optimum speed would be 7238 rpm with no change in the SFC (SFC = 0.4724).

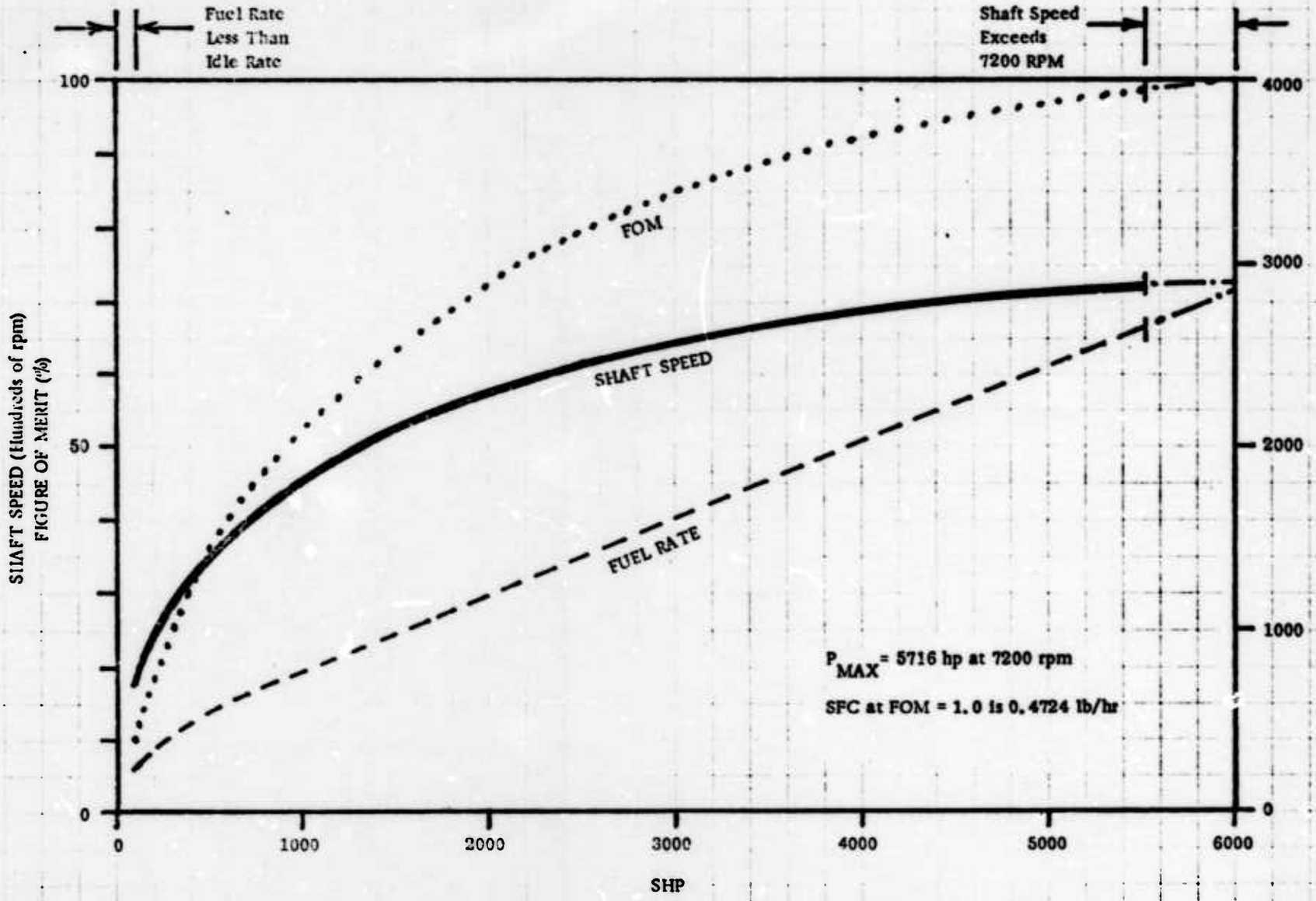


Figure A-4. Garrett 990 Turbine Model - Optimum Operating Conditions

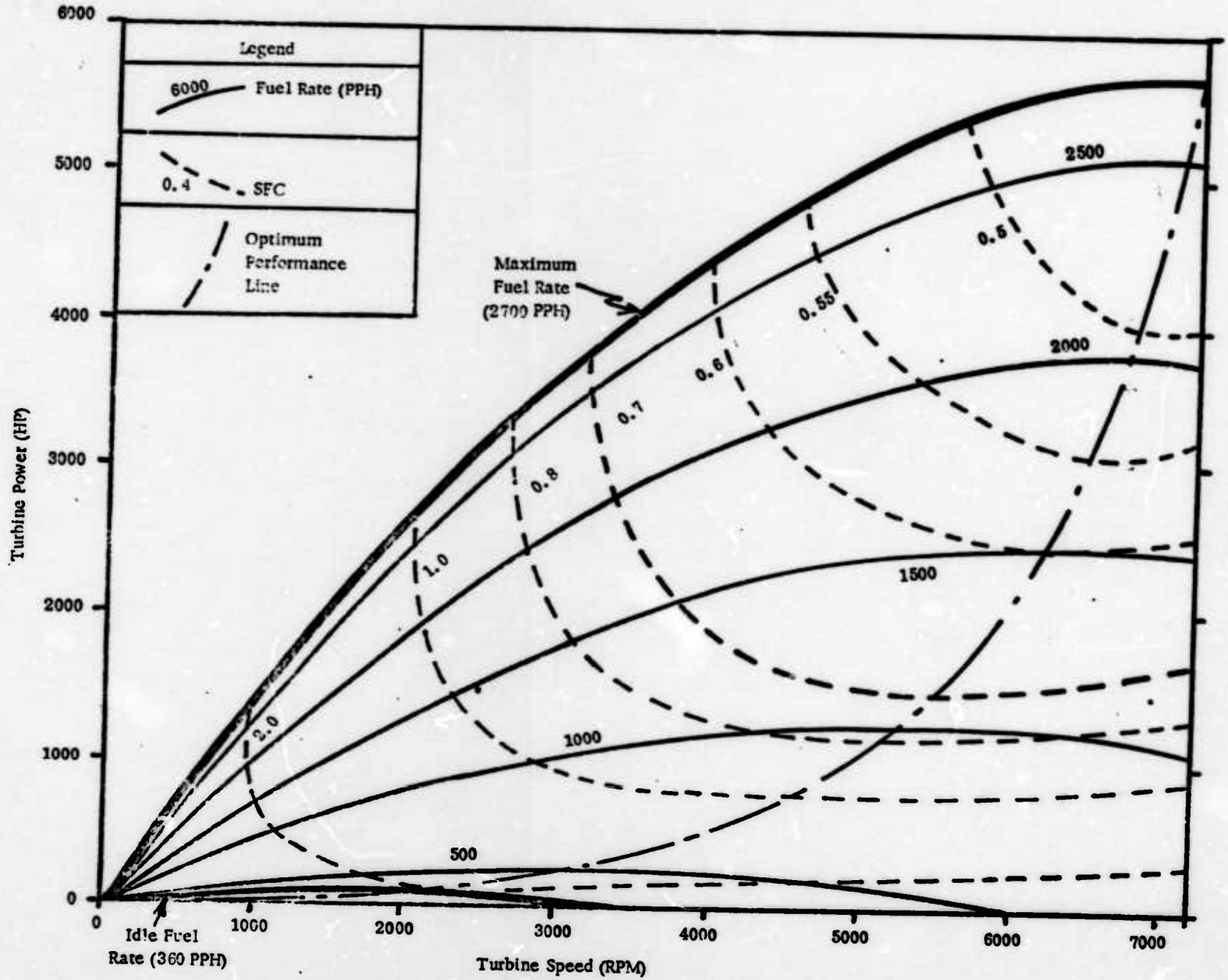


Figure A-5. Garrett 930 Turbine Model - Power and SFC Vs. Speed

Taking the gross heat of combustion of Navy distillate fuel as 19,300 btu/lb[1] and using 2545 btu/hp-hr gives a value of 0.1319 lbs of fuel/hp-hr for 100% conversion efficiency. For the two turbines:

	Min. SFC	Max. Thermal Eff.
Main	0.3814	0.3457
Cruise	0.4724	0.2791

and:

Thermal Eff. = FOM x (Max. thermal eff.)

The use of FOM, frees the analysis from fuel type and is used in the system analysis. In order to compare the two turbines on a common basis, the cruise turbine FOM is adjusted to account for its reduced thermal efficiency whenever comparisons are made between turbines. The adjusted cruise FOM is:

$$\text{Adjusted Cruise FOM} = \frac{\text{Main SFC}_{\text{Min}}}{\text{Cruise SFC}_{\text{Min}}} \times \text{FOM} = 0.8074 \times \text{FOM}. \quad (A7)$$

For the adjusted cruise FOM:

Thermal Eff = (Adj. FOM) x (Max. termal eff. for main turbine)

---

(1) R.J. Gauthey and J.P. DeTolla, "The Energy Crises and Naval Ship Research and Development," Naval Engineers Journal, 86, June 1974, p. 101.

A.2 PROPELLER MATH MODEL

In order to obtain a reasonable estimate of propeller performance, the behavior of thrust and torque coefficients for a standard propeller series[1] were linearized and modeled as follows:

$$C_T = T_M \left(1 - \frac{J}{T_0}\right) \tag{A8}$$

$$C_Q = Q_M \left(1 - \frac{J}{Q_0}\right) \tag{A9}$$

$$\left.\begin{aligned} T_M &= T_{M1} + T_{M2} R + T_{M3} R^2 \\ T_0 &= T_{01} + T_{02} R + T_{03} R^2 \\ Q_M &= Q_{M1} + Q_{M2} \ \text{Sine} \left[Q_{M3} (R - Rx) \right] \\ Q_0 &= Q_{01} + Q_{02} R + Q_{03} R^2 \end{aligned}\right\} \tag{A11}$$

Where: C_T = Thrust coefficient

C_Q = Torque coefficient

J = Advance coefficient

T_M = Value of C_T at $J = 0$

T_0 = Value of J at $C_T = 0$

Q_M = Value of C_Q at $J = 0$

---

(1) T.P. O'Brien, The Design of Marine Screw Propellers, Hutchison Scientific and Technical Publishers, London. Gawn standard screw series (pps. 88-92) was used to obtain the model form.

(Cont'd)

Q_0 = Value of J at $C_Q = 0$

R = Pitch to Diameter (P/D) ratio

T_{M1}, T_{M2}, T_{M3}, T_{01}, T_{02}, T_{03}, Q_{M1}, Q_{M2}, Q_{M3}, Q_{01}, Q_{02}, Q_{03} and RX are constants characterizing the propeller.

The following standard relationships are used:

$$J = \frac{v}{nD} = 101.3 \frac{V}{SD}$$

$$T = en^2 D^4 C_T$$

$$Q = en^2 D^5 C_Q$$

$$\eta_p = \frac{J}{2\pi} \cdot \frac{C_T}{C_Q}$$

(A12)

Where: v = Ship speed in fps

V = Ship speed in knots

n = Propeller speed in rev/sec

S = Propeller speed in rpm

D = Propeller diameter in feet

e = Water density in slugs/ft^3

T = Thrust in lbs

Q = Torque in lb - ft

η_p = Propeller efficiency

Maximum propeller efficiency occurs at:

$$J = Q_0\left[1 - \sqrt{1 - \frac{T_0}{Q_0}}\right] \quad \text{(J for max } \eta p\text{)}. \tag{A13}$$

The relationships between J, C_T, C_Q, T_0, T_M, Q_0, Q_M, and N are shown in figure A6.

For the propeller model used in the study the following values were used:

$T_{01} = 0.0500$	$Q_{01} = 0.4550$
$T_{02} = 1.0130$	$Q_{02} = 0.5470$
$T_{03} = 0.0060$	$Q_{03} = 0.1577$
$T_{M1} = -0.2600$	$Q_{M1} = 0.1830$
$T_{M2} = 1.0000$	$Q_{M2} = 0.1633$
$T_{M3} = -0.1800$	$Q_{M3} = 1.5160$
D = 17 ft	RX = 1.4250

$\rho = 1.9905$ slugs/ft^3.

These values were selected to:

a. Match the general characteristics of the Gawn standard screw series in terms of relative efficiencies at various pitches.

b. Provide approximately 72 to 73% efficiency under actual operation (selected arbitrarily as a reasonable efficiency).

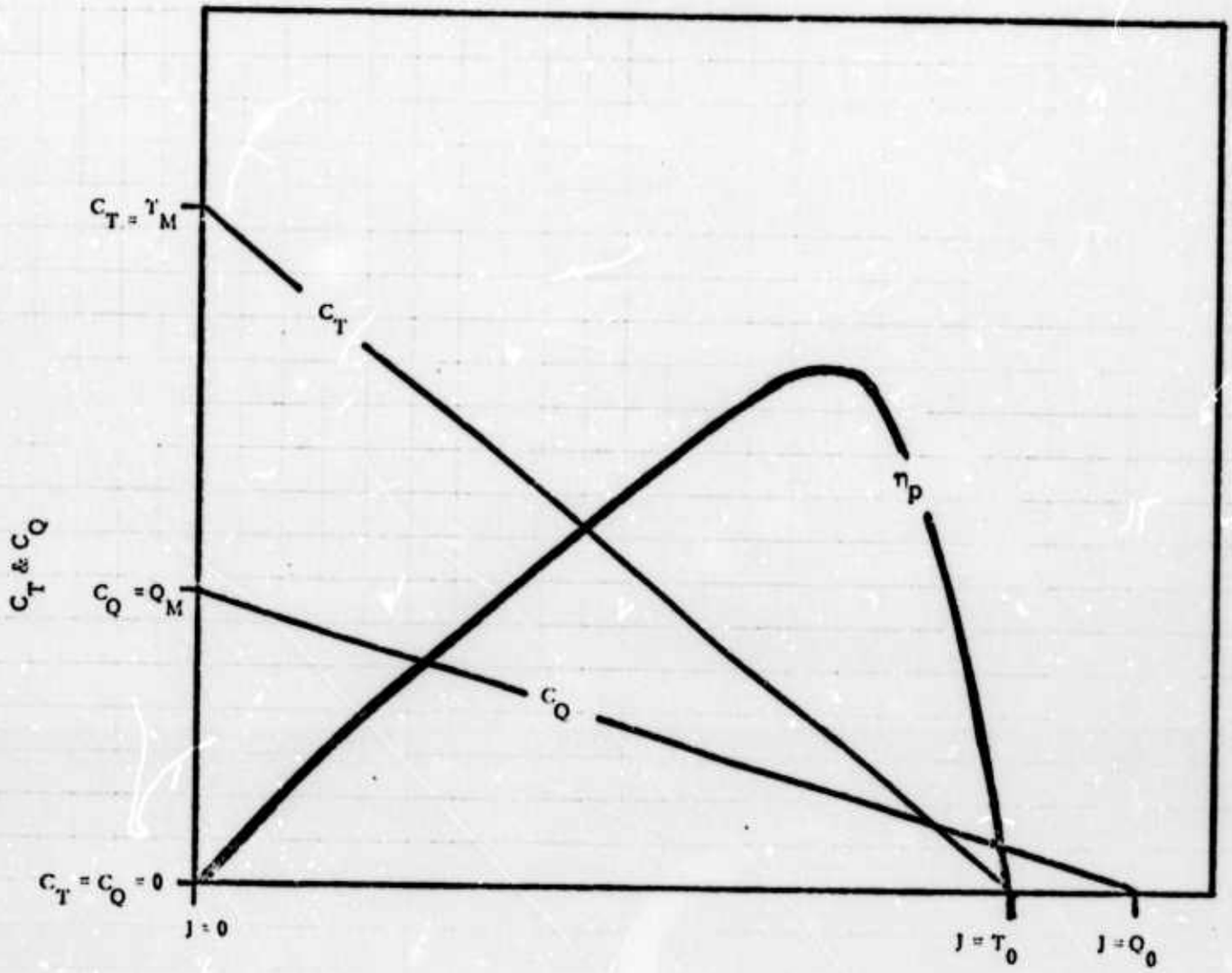


Figure A-6. Propeller Relationships

The values given for e and D provide the following characteristics:

$$J = 5.961 \frac{V}{S} \tag{A14}$$

$$T = 46.18 C_T \cdot S^2 \tag{A15}$$

$$Q = 785.1 C_Q \cdot S^2 \tag{A16}$$

The values given for T_{M1}, T_{M2}, etc. give the values shown in table A1.

Table A-1

Propeller Characteristics vs P/D

P/D	T_M	T_0	Q_M	Q_0	Maximum Efficiency	
					J	η_p
0.2735	0.0000	0.3275	0.02219	0.6164	0.1944	0.0000
0.3000	0.0238	0.3544	0.02118	0.6333	0.2131	0.0229
0.4000	0.1112	0.4562	0.01972	0.6990	0.2870	0.1620
0.5000	0.1950	0.5580	0.02201	0.7679	0.3664	0.3392
0.6000	0.2752	0.6600	0.02799	0.8400	0.4511	0.4825
0.7000	0.3518	0.7620	0.03753	0.9152	0.5408	0.5720
0.8000	0.4248	0.8642	0.05041	0.9935	0.6351	0.6260
0.9000	0.4942	0.9666	0.06632	1.0750	0.7335	0.6602
1.0000	0.5600	1.0690	0.08492	1.1597	0.8354	0.6852
1.1000	0.6222	1.1716	0.10576	1.2475	0.9397	0.7057
1.2000	0.6808	1.2742	0.12837	1.3385	1.0452	0.7237
1.3000	0.7358	1.3770	0.15224	1.4326	1.1504	0.7393
1.4000	0.7872	1.4800	0.17681	1.5299	1.2535	0.7523
1.5000	0.8350	1.5830	0.20153	1.6303	1.3525	0.7621
1.6000	0.8792	1.6862	0.22582	1.7339	1.4462	0.7686
1.7000	0.9198	1.7894	0.24912	1.8407	1.5336	0.7724
1.8000	0.9568	1.8929	0.27092	1.9505	1.6150	0.7746
1.9000	0.9902	1.9964	0.29069	2.0636	1.6911	0.7766
2.000	1.0200	2.1000	0.30799	2.1798	1.7627	0.7799

A.3 SHIP DRAG MODEL

The ship's drag characteristics were modeled as follows:

$$EHP = C_D \cdot V^3 \tag{A17}$$

$$C_D = C_{D0} \text{ for } V \leq 27 \text{ knots} \tag{A18}$$

$$C_D = C_{D0} \frac{V - C_2}{V_x - C_2} \text{ for } V \geq 27 \text{ knots}$$

$$D_S = \left(\frac{3600 \text{ sec/hr}}{6080 \text{ ft/mile}}\right) \cdot \left(550 \text{ lb - ft/sec/hp}\right) \cdot \frac{EHP}{V} \tag{A19}$$

$$= 325.7 \, C_D V^2$$

Where: EHP = Effective horsepower

V = Speed in knots

C_{D0}, C_2 and V_x are drag constants.

This form was chosen to approximate a V^2 dependence on drag at lower speeds with drag increasing faster in the 30-knot region. Values were chosen for the three constants of:

$C_{D0} = 1.4 \text{ hp/(kt)}^3$

$C_2 = 5$ knots

$V_x = 27$ knots

The resultant drag/power profile is given in table A2.

Table A-3

Ship Drag Characteristics

Speed (kts)	Drag (lbs)	Effective Hp	Speed (kts)	Drag (lbs)	Effective Hp
1.0	456.	1.40	19.0	164587.	9602.59
2.0	1824.	11.20	20.0	182368.	11199.99
3.0	4103.	37.80	21.0	201061.	12965.39
4.0	7295.	89.60	22.0	220666.	14907.19
5.0	11398.	175.00	23.0	241182.	17033.79
6.0	16413.	302.40	24.0	262610.	19353.59
7.0	22340.	480.20	25.0	284951.	21874.98
8.0	29179.	716.80	26.0	308202.	24606.38
9.0	36930.	1020.60	27.0	332368.	27556.19
10.0	45592.	1400.00	28.0	373689.	32129.70
11.0	55166.	1863.40	29.0	418286.	37248.61
12.0	65653.	2419.20	30.0	466282.	42954.48
13.0	77051.	3075.80	31.0	517801.	49290.50
14.0	89360.	3841.60	32.0	572968.	56301.31
15.0	102582.	4725.00	33.0	631906.	64033.13
16.0	116716.	5734.40	34.0	694740.	72533.63
17.0	131761.	6878.19	35.0	761594.	81852.19
18.0	147718.	8164.79	36.0	832594.	92039.44

A.4 TURBINE-PROPELLER-DRAG PERFORMANCE RELATIONSHIPS

A.4.1 Propeller/Drag Performance

The maximum propeller efficiencies given in table A1 cannot be attained unless the advance coefficient J is at the proper value. However, under steady-state operating conditions, the value of J is fixed by the relationship between propeller thrust coefficient and ship's drag, since the total propeller thrust must equal the drag at steady-state.

From A.2 and A.3:

$$T = 46.18\ C_T S^2 \qquad \text{(A15)}$$

$$D_S = 325.7\ C_D V^2 \qquad \text{(A19)}$$

$$J = 5.961\ V/S \qquad \text{(A14)}$$

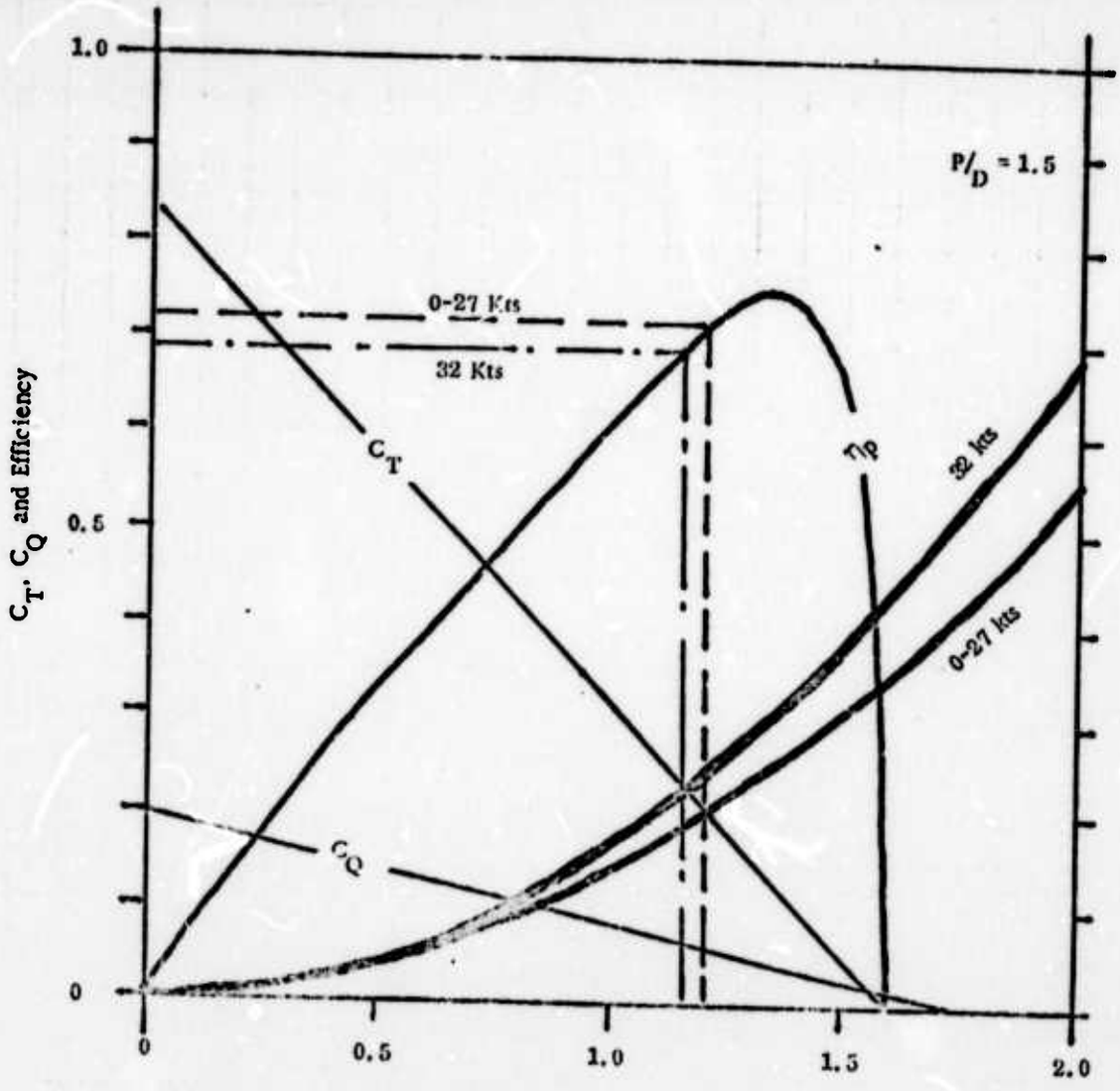
Combining ($D_S = 2T$):

$$C_T = 9.921 \times 10^{-2}\ C_D J^2$$

while, from A2:

$$C_T = T_M \left(1 - \frac{J}{T_0}\right) \qquad \text{(A8)}$$

Figure A7 shows the resulting operating points for a P/D ratio of 1.5. Operating efficiencies and advance coefficient, J, are given versus P/D ratio in table A3 and figure A8. For speeds up to 27 knots, maximum possible operating efficiency is 72.8% at a P/D ratio of 1.38; at 32 knots maximum efficiency is 71.3% at a 1.29 P/D ratio.



R = 1.5

T_M = 0.8350 Q_M = 0.2015

T_0 = 1.5830 Q_0 = 1.6303

For Maximum η_p:

J = 1.353

η_p = 76.2%

Operating Point for <u>0-27 kts:</u>

J = 1.202

η = 72.6%

C_T = 0.2010

C_Q = 0.05294

Operating Point for <u>32 kts:</u>

J = 1.153

η = 70.6%

C_T = 0.2268

C_Q = 0.05899

Figure A-7. Propeller Operation With PD = 1.5

P/D Ratio	Maximum Propeller Efficiency	Operating[1] Propeller Efficiency	Advance[1] Coefficient (j)
0.2735	0	0	0
0.3	0.023	0.022 - 0.023	0.238 - 0.225
0.4	0.162	0.129 - 0.138	0.375 - 0.364
0.5	0.339	0.269 - 0.289	0.469 - 0.456
0.6	0.483	0.404 - 0.430	0.557 - 0.541
0.7	0.573	0.510 - 0.534	0.637 - 0.620
0.8	0.626	0.587 - 0.607	0.718 - 0.696
0.9	0.660	0.643 - 0.655	0.795 - 0.769
1.0	0.685	0.681 - 0.685	0.869 - 0.841
1.1	0.706	0.706 - 0.703	0.940 - 0.909
1.2	0.724	0.720 - 0.711	1.009 - 0.972
1.3	0.739	0.727 - 0.713	1.076 - 1.037
1.4	0.752	0.728 - 0.710	1.140 - 1.095
1.5	0.762	0.726 - 0.706	1.202 - 1.149
1.6	0.769	0.723 - 0.700	1.262 - 1.209
1.7	0.772	0.719 - 0.695	1.319 - 1.263
1.8	0.775	0.716 - 0.691	1.374 - 1.312
1.9	0.777	0.715 - 0.689	1.426 - 1.361
2.0	0.780	0.716 - 0.690	1.476 - 1.406

[1] First value is for 0 to 27 kts; second is for 32 kts.

Table A-3. Propeller Operating Efficiency Versus P/D Ratio

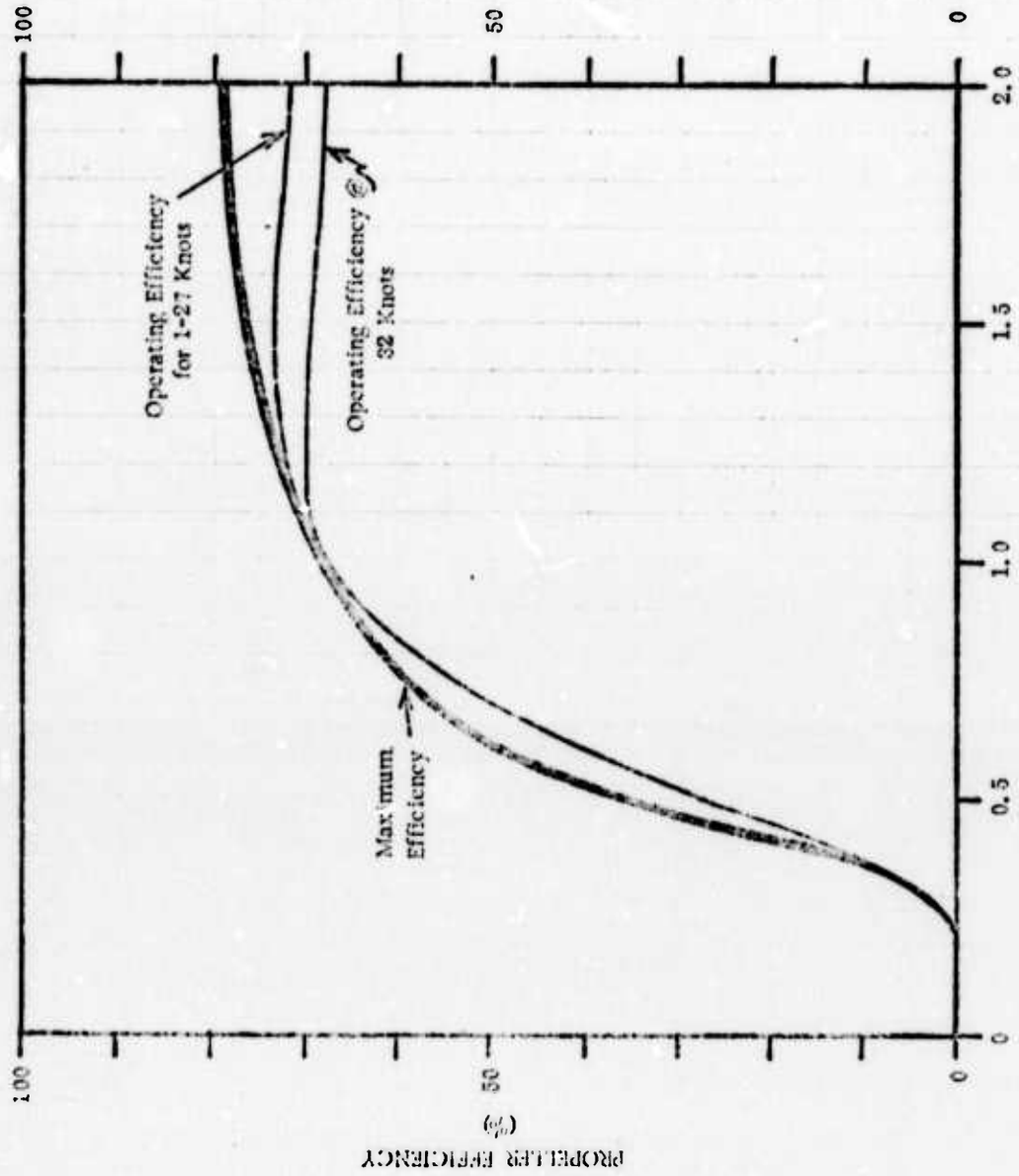


Figure A-8. Propeller Efficiency vs. P/D Ratio

From Section A.2,

$$J = 5.961 \frac{V}{S} \qquad \text{(A14)}$$

This results in a limitation on P/D ratio if propeller shaft speed is limited; for example, 32 knots:

Maximum Allowed Shaft rpm	Minimum Allowable P/D Ratio
160	1.57
165	1.51
170	1.45
175	1.39
180	1.34

A.4.2 Propeller/Turbine Performance

A.4.2.1 Optimum Pitch

As discussed in A.4.1 and A.1, propeller efficiency and turbine efficiency are both affected by shaft rpm. If there is a fixed mechanical gear ratio between the propeller shaft and turbine, the optimum P/D ratio for minimum fuel rate will occur at some value other than that for the turbine or propeller alone. For example, with two main turbines operating at 23 kts and 96% drive efficiency:

Maximum Propeller Efficiency = 0.728 at 120 rpm
With a P/D ratio of 1.4

Maximum Turbine FOM = 0.862 at 3392 rpm
With an output of 26,050 hp

If the gear ratio were 28.3 to 1 (3392 rpm/120 rpm), the turbine would deliver 25,010 shaft hp and effective power would be 18,210 hp with an (ideal) efficiency of:

$$0.728 \times 0.862 \times 0.960 = 0.602.$$

However, with a fixed gear ratio of 21.5 to 1, optimum performance occurs as shown in figure A9:

P/D Ratio	= 1.27
Shaft Speed	= 130 rpm
Turbine Speed	= 2783 rpm
Effective Power	= 17,030[1]

[1] Fixed at 17,030 hp by drag at 23 knots.

Shaft Power	= 23,470 hp
Turbine Power	= 24,450 hp[1]
Fuel Rate	= 10,930 lbs/hr
Propeller Efficiency	= 0.726
Turbine FOM	= 0.853
Drive Efficiency	= 0.960
Overall Propulsion Efficiency	= 0.594

For the same conditions (23 knots with two main turbines) the electrical drive system is optimized by adjusting the "gear ratio" through reduction of the generator magnetic field and optimizes as follows:

P/D Ratio	= 1.35
Shaft Speed	= 124 rpm
Turbine Speed = 2960 rpm	(76.6% magnet field)
Effective Gear Ratio	= 23.9 to 1
Effective Power	= 17,030 hp
Shaft Power	= 23,040 hp
Turbine Power	= 24,100 hp
Fuel Rate	= 10,800 lbs/hr
Propeller Efficiency	= 0.728
Turbine FOM	= 0.852[2]
Drive Efficiency	= 0.971
Overall Propulsion Efficiency	= 0.602

---

(1) Turbine Power = (Effective hp)/(propulsion efficiency x drive efficiency)

(2) The slight decrease over the geared case in turbine FOM reflects the drop in turbine power required; 0.852 is the maximum FOM for 24,100 hp from two turbines.

The electric drive is thus 1.3% more efficient at 23 knots; at lower speeds the difference is more pronounced, leading to an overall 6-7% advantage for the electric drive when averaged over the mission profile.

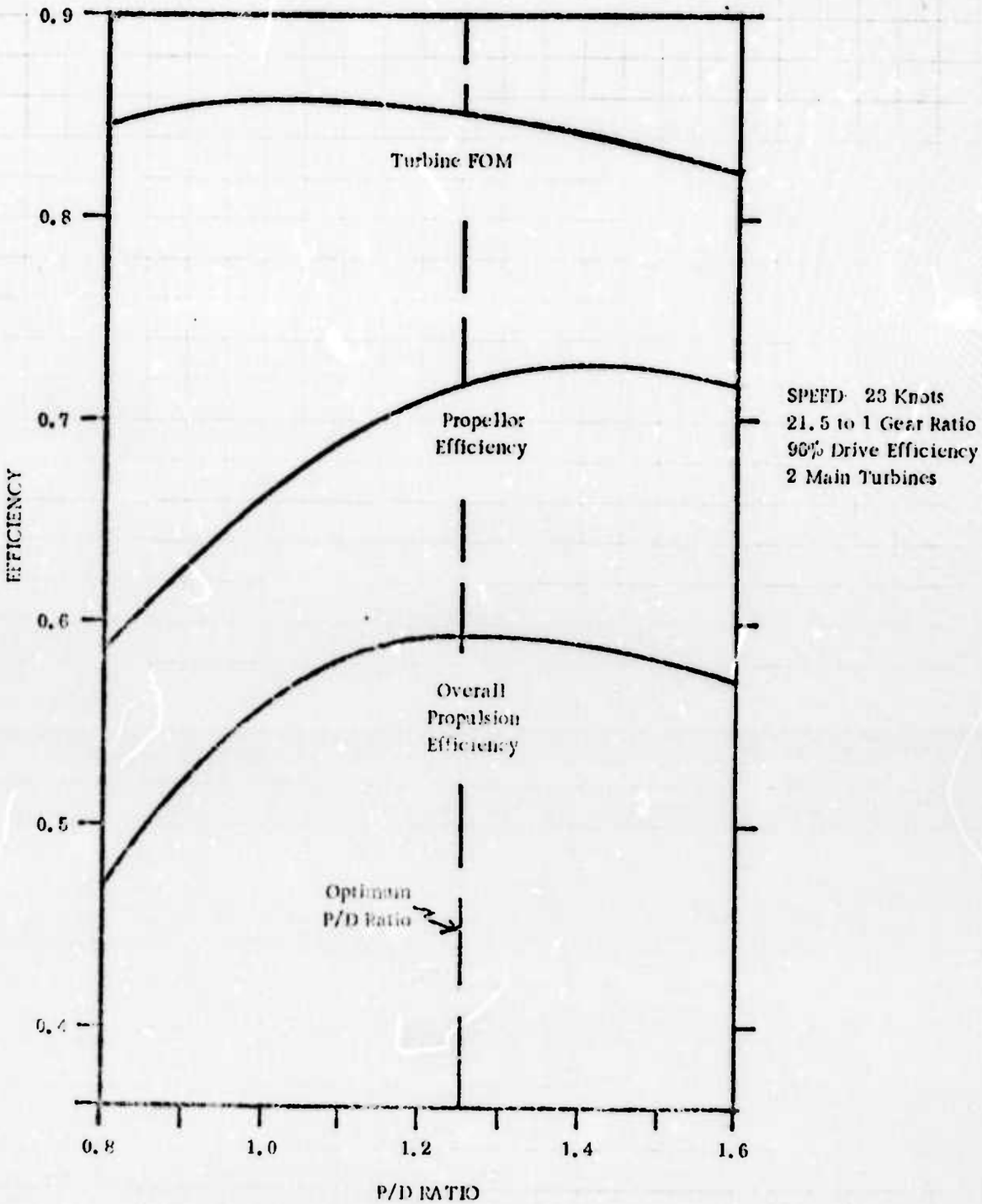


Figure A-9. Operating Point With Fixed Gear Ratio

A.4.2.2 Selection of Gear Ratios and Electric Machinery Voltages

The propeller pitch determines the propeller rpm at each speed; turbine rpm and efficiency then depend on the gear ratio, in the geared drive case, and on the motor/generator emf (volts/rpm), in the electric drive case. The combination is limited by:

- Propeller cavitation
- Turbine upper speed limit.

In order to determine the optimum gear ratios for the turbines and the optimum electric machine voltages, the system math model was exercised subject to the following constraints:

- Propeller limited to 168 rpm(1)
- Main turbine limited to 3600 rpm
- Cruise turbine limited to 7200 rpm

The results gave, for minimum fuel consumption:

- Main Gear Ratio 21.5 to 1
- Cruise Gear Ratio: 74.0 to 1
- Electric Motor emf: 1.6328 v/rpm(2)
- Main Generator: 0.0911 v/rpm(2) .
- Cruise Generator: 0.0209 v/rpm(2)

---

(1) Based on cavitation; see, D.A. Rains and R.J. d'Arcy, "Considerations in the DD 963 Propulsion System Design," Naval Engineers Journal, August 1972, p. 68.

(2) The electric drive system has a variable "gear ratio" with minimum values of 17.9 to 1 for the main turbines and 78 to 1 for the cruise turbines.

A.4.2.3 Selection of Operating Pitches

With the gear ratios and electrical constants established, the optimum propeller pitch for each speed was determined. The result for the geared drive with main turbines is shown in figure A10. Below 5 knots with one turbine, and below 7 knots with two turbines, pitch must be used to regulate speed because the turbine fuel rate is at its minimum value of 1100 lbs/hr per turbine. At 5 knots, the optimum pitch for 1 turbine is 1.15; it drops to 1.06 at 11 knots and then rises to 1.16 at 21 knots. Similar effects occur for each combination of turbines. A continuously variable pitch is undesirable for cruise conditions, since the minimum fuel rate can be closely approached by using a fixed pitch for each combination of turbines in use.

Based on the results shown in figure A9 and similar results for the cruise turbines, fixed pitch ratios were selected for each combination of turbines. These values were verified as giving optimum performance by inserting them in the math model and running them over the mission profile. The values selected were:

Number of Turbines	Baseline System	Baseline +Alternators	Baseline +Cruise Turbines	Alternators +Cruise Turbines
1 Cruise	-	-	-	1.10
2 Cruise	-	-	1.25	1.30
1 Main	-	1.10	-	1.10
2 Main	1.20	1.30	1.30	1.30
3 Main	-	1.40	-	1.40
4 Main	1.50	1.50	1.50	1.50

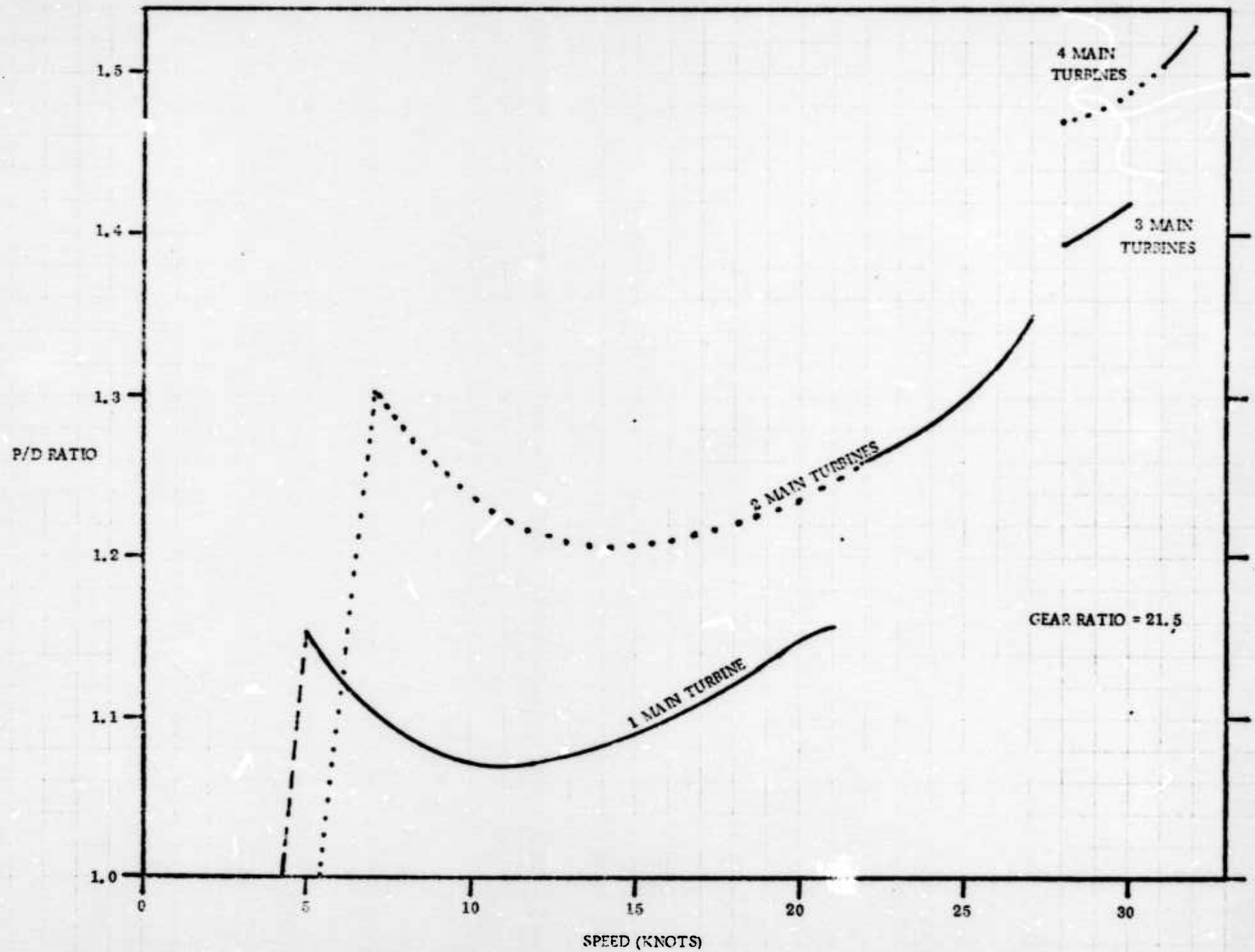


Figure A-10. Optimum P/D Ratio vs. Speed - Geared Drive

For the electric system, the optimum pitch is much closer to the pitch (1.38) where maximum propeller efficiency occurs, as shown in figure A11[1]. Because of the small variation in optimum pitch in the electric drive case, it is advantageous to use a fixed pitch propeller and a single pitch was therefore selected for the electric drive. The minimum fuel consumption over the mission profile occurs for a P/D ratio of 1.35; however, this requires a propeller speed of 179 rpm at 32 knots. In order to keep propeller speed close to 168 knots, a fixed P/D ratio of 1.45 was selected resulting in 169.6 rpm at 32 knots (a P/D of 1.50 would give 165.4 knots and the nearest 0.05 variation in P/D was selected).

(1) Pitch is set to 1.5 when the turbine fuel rate is at idle and speed is controlled by varying the magnet field.

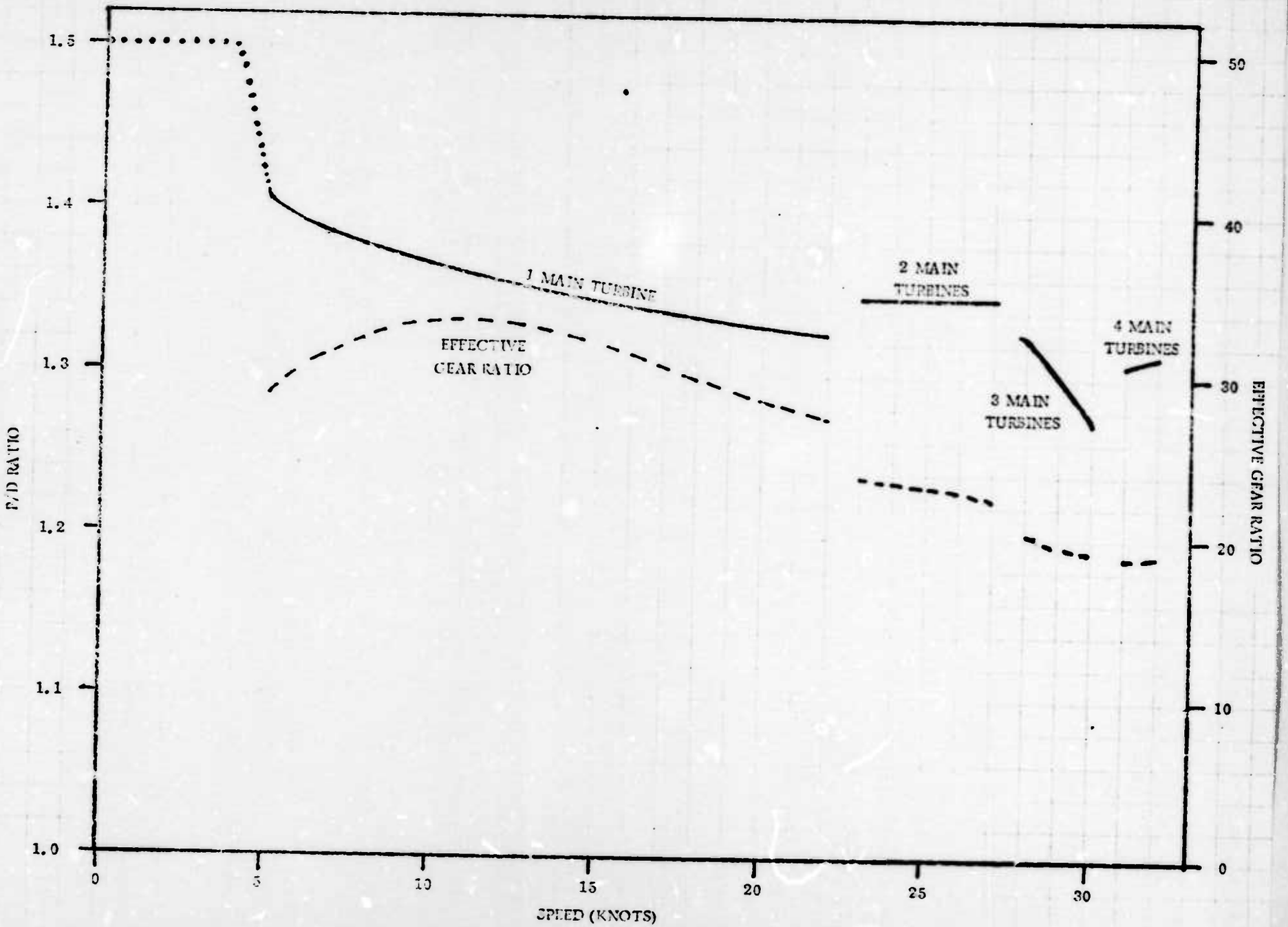


Figure A-11. Optimum P/D Ratio vs. Speed - Electric Drive

A.5 ENDURANCE CALCULATIONS

Endurance calculations are based on BUSHIPS Design Data Sheet DDS 9400-1[1]. Values of endurance and endurance speed used to calculate endurance fuel load were selected to match those of the DD-931 and DL-2: 4500 miles at 20 knots[2].

Endurance power and fuel rate were taken from the baseline math model analysis. Ships service electric load was estimated at 4,000 kw at a fuel rate of 0.8 lb/kw-hr (see Appendix B) and "fuel consumption for other services" was estimated at 10% of the ships service electric load. A "tailpipe allowance factor" of 0.95 was selected (i.e. 5% of the fuel is unavailable). The endurance fuel load calculations, based on DDS 9400-1, are shown in Table A4. The result of the calculation is 1428 long tons of fuel; 1430 tons was selected as the endurance fuel load.

---

(1) Design Data Sheet DDS 9400-1, "Calculation of Surface Ship Endurance Fuel Requirements," 1 Nov. 1963.

(2) R.T. Miller, C.L. Long and S. Reitz, "ASW Surface Ship of the "80's" Study," Naval Engineers Journal, Dec. 1972, p. 15.

Table A-4

ENDURANCE FUEL LOAD[1]

(1)	Endurance	4,500 n. miles[2]
(2)	Endurance Speed	20 knots[2]
(3)	Full Load Displacement	7,600 l. tons
(4)	Full Rated Power	80,000 SHP
(5)	Endurance Power at (2) and (3)	15,500 SHP[3]
(6)	Avg. Endurance Power = 1.1 x 5	17,100 SHP
(7)	Ratio: (6) / (4)	0.21
(8)	Cruising Electric Load	4,000 kw[4]
(9)	Fuel Rate at (6)	0.517 lb/SHP-hr[3]
(10)	Prop. Fuel Consumption = (6) x (9)	8,850 lbs/hr
(11)	Aux. Gen. Fuel Rate at (8)	0.8 lb/kw-hr[4]
(12)	Aux. Gen. Fuel Consumption = (8) x (11)	3,200 lb/hr
(13)	Fuel Consumption for Other Services	320 lb/hr[5]
(14)	All-Purpose Fuel Consumption = (10) + (12) + (13)	12,370 lb/hr
(15)	All-Purpose Fuel Rate = (14) / (6)	0.723 lb/SHP-hr

(1) Ref: BUSHIPS Design Data Sheet DDS 9400-1, "Calculation of Surface Ship Endurance Fuel Requirements," 1 Nov. 1963.

(2) Values selected to equal DD-931 and DL-2.

(3) Values from baseline model.

(4) Estimated values for ships service.

(5) Estimated at 10% of auxiliary generator fuel consumption.

Table A-4 (Cont'd)

(16)	Fuel Rate Correction Factor based on (7)	1.04 (1)
(17)	Specific Fuel Rate = (15) x (16)	0.752 lb/SHP-hr
(18)	Endurance Fuel Rate = (17) x 1.05 (2)	0.790 lb/SHP-hr
(19)	Burnable Fuel = (1) x (6) x (18) /((2) x 2240)	1,357 l.tons
(20)	Tailpipe Allowance Factor	0.95 (3)
(21)	Endurance Fuel Load = (19) / (20)	1,428 l.tons

(1) Value from ref. (1) above; (1.04 applies for (7) ≤ 1/3).

(2) Value from ref. (1) above; represents arbitrary 5% increase in fuel rate to allow for deterioration over two-year period.

(3) Value from ref. (1) above; 0.95 factor selected for broad, shallow tanks.

The endurance fuel load computation reduces to:

$$4.935 \times 10^{-4} K \left(\frac{\text{Endurance}}{\text{End. Speed}}\right) \left(\text{All-Purpose Fuel Consumption}\right)$$

Where:

K = Fuel Rate Correction Factor

$= 1.04$ for $\left(\frac{\text{SHP}}{\text{Full Rated Power}}\right) \leq 0.33$

$= 1.03$ for $0.34 \leq \left(\frac{\text{SHP}}{\text{FRP}}\right) \leq 0.66$

$= 1.02$ for $\left(\frac{\text{SHP}}{\text{FRP}}\right) > 0.67$

All-Purpose Fuel Consumption = (Propulsion Fuel Consumption[1]) + (Auxiliary Generator Fuel Consumption) + (Fuel Consumption for other Services).

Conversely:

$$\text{Range (Endurance)} = \frac{2027 \text{ (Speed) (Endurance Fuel Load)}}{K \text{ (All-Purpose Fuel Consumption)}} \qquad (A20)$$

(1) Taker [illegible] of power required at endurance speed in endurance fuel l[illegible]ulations (allows for adverse sea conditions and bottom fouling [illegible]. a two year period).

In order to provide a comparison between various configurations, range was calculated according to the above expression. The total of auxiliary generator and other services was held fixed at 3520 lb/hr in all calculations. Fuel rate was taken from the computer results at each speed[1] and an allowance was made for additional ships service load as follows:

Added Ship Service Load (kw) = (Cooling Load)

+ (Refrigeration Load) + (Lubrication Load)

Where:

Cooling Load (kw) = 0.02 (Turbine HP - Shaft HP)

(Estimated ship service load required for pumping coolant and seawater to remove heat generated by losses).

Refrigeration Load = Power required for helium compressors

Lubrication Load = Power required for lubrication of electrical generators[2].

Added Fuel Load (lb/hr) = 0.8 x (Added Ships Service Load)

---

(1) No 110% adjustment factor used on power.

(2) Motor lubrication considered even tradeoff against mechanical gear system.

Example:

Electric drive system with cruise turbines at 25 knots; two main turbines operating:

Turbine HP = 30980
Shaft HP = 30040
} 19 kw cooling load

Refrigeration Load = 130 kw

Lubrication Load = 2 kw (Two Generators)

Total added ships service load: 151 kw

x 0.8 = 121 lb/hr added fuel load

Fuel rates:

Turbines: 12,890 lb/hr

Added Load: 121 lb/hr

Ships Service: 3520 lb/hr

Total: 16,531 lb/hr (All-purpose fuel rate)

$\dot{SHP} \div$ Rated Power (80,000 HP) = 0.38; K = 1.03

$$\text{Range} = \frac{2027\ (25)\ (1430)}{1.03\ (16531)} = 4256 \text{ miles}$$

Average results over the mission profile are based on the average mission speed of 15.8 knots and the average power loss and lubrication load. The endurance fuel load is reduced by the weight of any added propulsion equipment.

i.e., over the mission profile:

$$\text{Range} = \frac{2027\ (15.8)\ (1430 - \text{Added Equipment Weight})}{1.04\ (\text{Average All-Purpose Fuel Consumption})}$$

$$= \frac{30795\ (1430 - \text{Added Weights})}{(\text{Average All-Purpose Fuel Consumption}} \qquad (A21)$$

Example:

For the geared-drive baseline:

Average Turbine HP = 10770
Average Shaft HP = 10340
} 9 kw cooling load

Refrigeration Load = 0

Lubrication Load = 0

9 kw total load (7 lb/hr)

Fuel Rates:

Average Turbine Fuel Rate = 6392 lb/hr

Average Added Load = 7 lb/hr

Ships Service Load = 3520 lb/hr

9919 lb/hr total

Added Weight = 0

$$\text{Range} = \frac{30795\ (1430)}{9919} = 4440 \text{ miles}$$

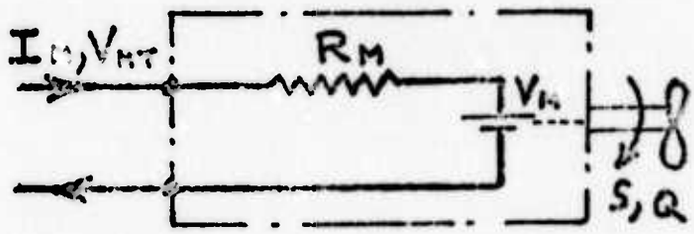
A.6 ELECTRIC DRIVE MATH MODELS

Math models for the electric motors, generators, tranmission lines, and buss lines are shown in figures A-12 through A-14.

A.7 ALTERNATOR MATH MODEL

Analysis of the crossover efficiency, as shown in figure A-15 gives an expression for drive system efficiency in the crossover mode equal to 0.921 for a drive efficiency of 0.96 and alternator efficiencies of 0.98 each. The same result is obtained by using $0.96 \times (0.98)^2$; i.e., by multiplying the drive efficiency by the alternator pair efficiency of 0.96. The latter method is used in the computer program whenever crossover is used.

MOTOR MATH MODEL



I_M = Input Current (Amps)

V_{MT} = Terminal Voltage

V_M = Back emf (volts)

R_M = Internal resistance (ohms)

S = Shaft rpm

Q = Shaft torque (lb-ft)

K_M = Back emf (volts/rpm)

K_F = Friction loss (Kw/rpm^2)

K_E = Eddy current loss (Kw/rpm^2)

K_V = Viscous loss (Kw/rpm^3)

Given S and Q (from propeller characteristics)

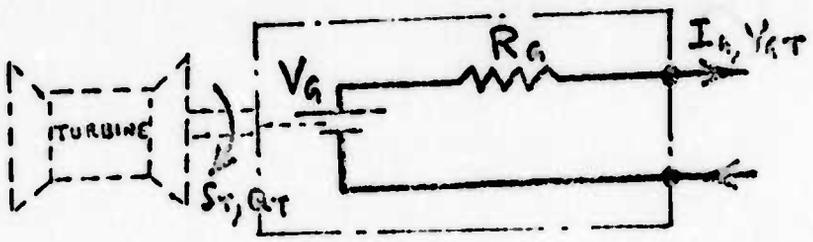
$$I_M = \frac{0.1428\ S \cdot Q + 1000\ (K_F S^2 + K_E S^2 + K_{VM} S^3}{K_M S}$$

$$V_M = K_M S$$

$$V_{MT} = V_M + I_M R_M$$

Figure A-12

GENERATOR MATH MODEL



I_G = Generator Current (amps)

V_{GT} = Terminal Voltage

V_G = Back emf (volts)

R_G = Internal Resistance (ohms)

S_T = Shaft (turbine) rpm

P_T = Turbine hp

K_G = Back emf (volts/rpm)

K_F = Friction loss (Kw/rpm^2)

K_E = Eddy current loss (Kw/rpm^2 at full field)

K_V = Viscous loss (Kw/rpm^3)

P_f = Percent magnet field

Given I_G and V_{GT} (from Buss Line):

$$V_G = V_{GT} - I_G R_G$$

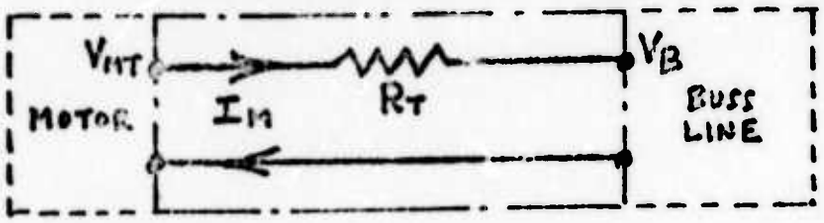
$$S_T^* = \frac{V_G}{P_f K_G}.$$

$$P_T^* = \frac{I_G V_G + 1000 \left[K_F S_T^2 + K_E \left(P_f S_T \right)^2 + K_V S_T^3 \right]}{745.7}$$

* S_T and P_T are a function of the percent magnet field.

Figure A-13

TRANSMISSION LINE MATH MODEL



V_{MT} = Motor terminal voltage

V_B = Buss voltage

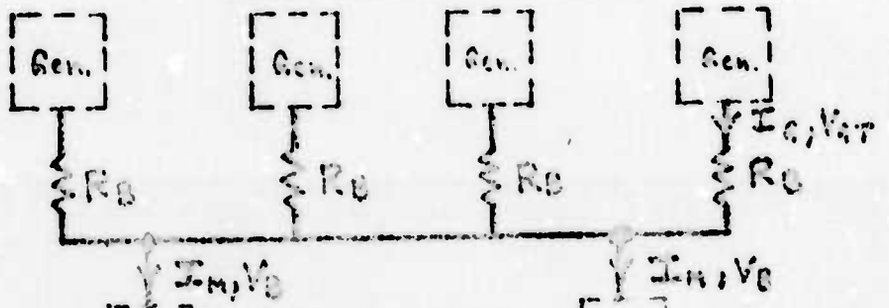
I_M = Motor current (amps)

R_T = Transmission line resistance (ohms)

Given I_M and V_{MT} (from motor):

$$V_B = V_{MT} + I_M R_T$$

BUSS LINE MATH MODEL



I_M = Motor current (amps)

I_G = Generator current (amps)

V_B = Buss voltage

V_{GT} = Generator terminal voltage

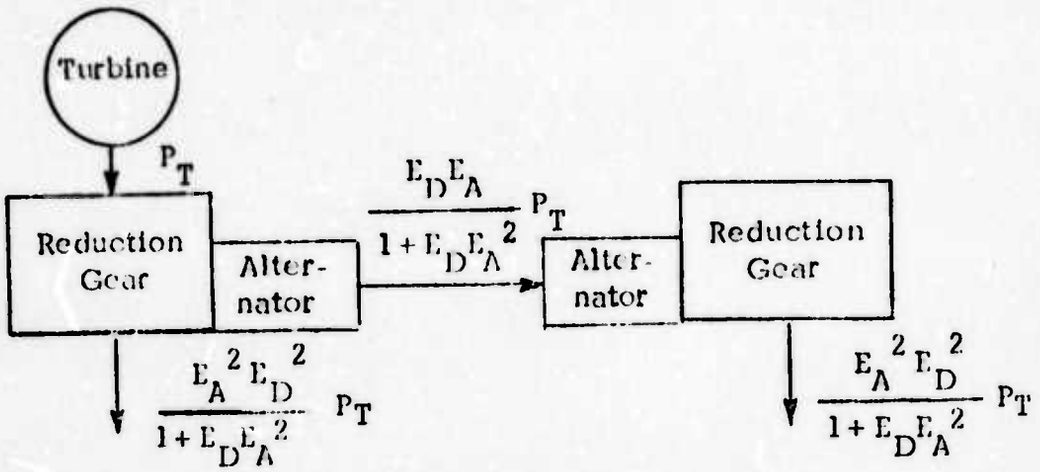
R_B = Buss resistance

N_T = No. of turbines operating

Given I_M and V_B (from transmission line):

$$I_G = \frac{2 I_M}{N_T} \qquad V_{GT} = V_B + I_G R_B$$

Figure A-14



$$\text{Overall efficiency} = 2\left(\frac{E_A^2 E_D^2}{1+E_D E_A^2}\right)$$

Where:

P_T = Turbine Shaft Power

E_A = Alternator Efficiency

E_D = Drive Efficiency

For $E_A = 0.98$ and $E_D = 0.96$:

Power transferred = $0.489\ P_T$

Efficiency = 0.921

Figure A-15. Alternator Math Model

APPENDIX B - SYSTEM COMPONENTS

This appendix contains details of the superconductive motors, generators and ancillary equipment used as a basis for electric drive performance in the study, as well as the alternator design used for the geared systems.

B.1 MOTORS

The motor design used is based on a design developed at NSRDC, Annapolis, Maryland[1]; essential details are shown in figure B-1.

B.2 MAIN GENERATORS

The 20,000 hp main generator design is also based on an NSRDC design[2] and is shown in figure B-2.

B.3 CRUISE GENERATORS

The 5,000 hp cruise generator is similar to a 5,000 hp, 15,000 rpm generator design developed at NSRDC. The generator was redesigned to operate at 7,200 rpm for use with the Garrett 990 gas turbine and machine losses and helium requirements were estimated using techniques

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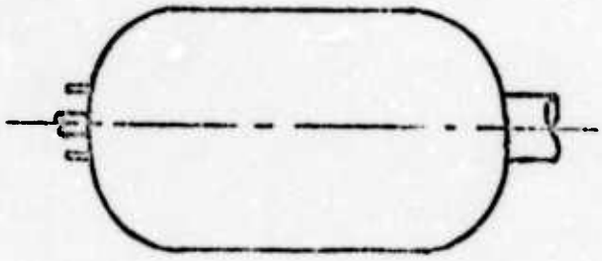
(1) T. J. Doyle, "Superconductive Propulsion Motor Development at NSRDC," Naval Ship Research and Development Center, Annapolis, Maryland, August, 1974.

(2) H.O. Stevens, "Superconductive Generation Development for Ship Electric Drive Systems," Naval Ship Research and Development Center, Annapolis, Maryland, August, 1974.

40,000 HP SUPERCONDUCTING MOTOR



Design Point:

40,000 hp at 180 rpm
(30,510 kw at 300 v)

Size:

OD:	6.47 ft
Length:	11.67 ft
Volume:	384 ft^3

Weight:

Machine weight:	130,000 lbs
Mount weight:	6,500 lbs
Total weight:	136,500 lbs

Performance at Design Point:

Power Input: 30,5[illegible] (40,915 hp)

Losses:	Ohmic	620.6 kw
	Brush Eddy Current	59.2 kw
	Brush Viscous Drag	0.4 kw
	Bearing, Seals and Windage	2.1 kw
		682 kw total (915 hp)

Power Output: 40,000 hp (29,828 kw)
Current: 101,700 amps
Voltage: 300 volts Efficiency: 97.76%

Helium Required:

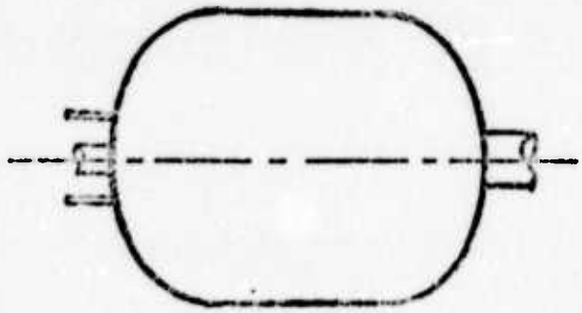
0.097 gm/sec at 4.5 K, 1.1 atmosphere

Design Constants:

K_M	(Back emf):	1.6328 v/rpm
R_M	(Internal Resistance):	60 micro-ohms
K_F	(Friction Loss):	6.481 x 10^{-}[illegible] $kw/(rpm)^2$
K_E	(Eddy Current Loss):	1.827 x 10^{-3} $kw/(rpm)^2$ (at full field)
K_V	(Viscous Loss)	6.859 x 10^{-8} $kw/(rpm)^3$

Figure B-1

20,000 HP SUPERCONDUCTING MAIN GENERATOR



Design Point: 20,000 hp @ 3300 rpm
(14,800 kn @ 300v)

Size		Weight	
OD:	3.17 ft	Machine Weight:	10,000 lbs
Length:	4.17 ft	Mount Weight:	500 lbs
Volume:	32.8 ft	Total Weight:	10,500 lbs

Performance at design point:

Power Input: 20,000 hp (14,914 kw)

Losses:		
	Ohmic:	27.3 kw
	Brush Eddy Current:	27.8 kw
	Brush Viscous Drag:	31.2 kw
	Bearings, Seals & Windage:	20.0 kw
		106 kw Total

Power Output: 14,808 kw
Current: 49,360 amps
Voltage: 300 volts Efficiency: 99.29%

Helium Required: 0.045 gm/sec at 4.5 K, 1.1 atmosphere

Design Constant s:

K_a (Back emf): 0.09111 volts/rpm

R_a (Internal Resistance): 11.2 micro-ohms

(Friction Loss): 1.8365×10^{-6} kw/(rpm)^2

K_e (Eddy Current Loss): 2.553×10^{-6} kw/(rpm)^2 (At full Field)

K_v (Viscous Loss): 8.682×10^{-10} kw/(rpm)^3

Figure B-2

similar to those used at NSRDC[1]. The final design is shown in figure B-3.

B.4 AC-DC GENERATOR

Garrett Airesearch Manufacturing Company has proposed a non-superconducting 5,000 hp ac-dc generator for use with the Garrett 990 turbine[2]. This generator develops the dc power required by the superconducting motors by generating ac power which is then rectified to dc by a bank of 120 diodes. The machine is less efficient than the superconducting cruise generator (96.5% against 99.2%) and weighs about 1-1/2 times as much. It has the advantages of not requiring liquid helium cooling and an ability for rapid changes in field excitation (very rapid field changes are not possible in the superconducting machine because of magnet and inductance limitations). The use of the ac-dc generator as a substitute for the superconducting generator is discussed in the text. Figure B-4 gives the essential design details.

B.5 ALTERNATOR

The alternator used as a basis for the geared drive crossover systems is also based on Airesearch designs developed for NAVSHIPS. It is, essentially, the ac-dc generator design without

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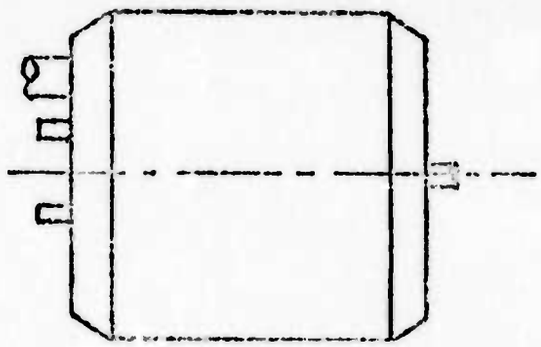
(1) T.J. Doyle and M.J. Cantrell, "Development of the Shaped Field Superconductive Motor," Naval Ship Research and Development Center, Bethesda, Maryland, Report No. 4178, January 1974.

(2) Work performed under the auspices of the U.S. Navy Naval Ships System Command under Contract No. N0024-73-C-5487.

5,000 HP SUPERCONDUCTING CRUISE GENERATOR



Design Point:

5,000 hp @ 7,200 rpm
(3,700 kw @ 150 v)

Size:

OD:	2.33 ft
Length:	2.33 ft
Volume:	10.0 ft^3

Weight

Machine weight:	3,500 lbs
Mount weight:	350 lbs
Total weight:	3,850 lbs

Performance at Design Point:

Power Input: 5,000 hp (3,728 kw)

Losses:	Ohmic	14.6 kw
	Brush Eddy Current	3.0 kw
	Brush Viscous Drag	1.8 kw
	Bearings, Seals and Windage	9.0 kw
		28 kw total

Power Output: 3,700 kw
Current: 24,640 amps
Voltage: 150 volts Efficiency: 99.24%

Helium Required:

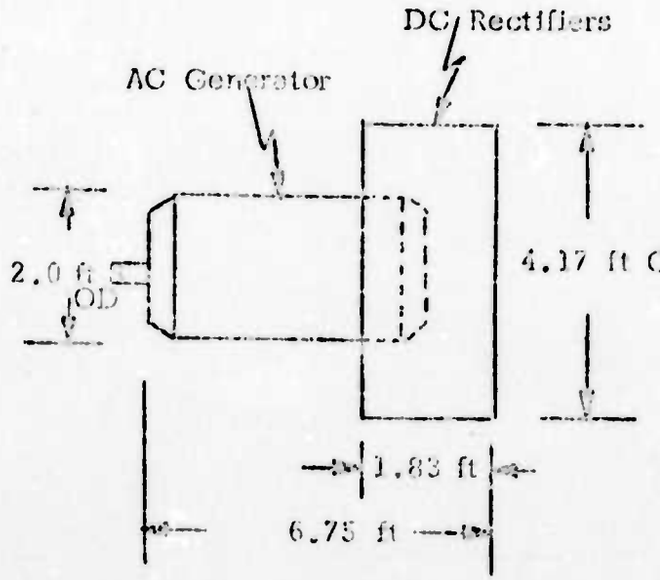
0.051 gm/sec at 4.5° K, 1.1 atmosphere

Design Constants:

K_b (Back emf):	0.0209 volts/rpm
R_C (Internal Resistance):	24 micro-ohms
K_f (Friction Loss):	0.3736×10^{-6} kw/(rpm)^2
K_e (Eddy Current Loss):	0.0579×10^{-6} kw/(rpm)^2 (at full filed)
K_V (Viscous Loss):	4.8225×10^{-12} kw/(rpm)^3

Figure B-3

5,000 HP AC-DC GENERATOR



Design Point:
5,000 hp at 7200 rpm
(3,741 kw at 152 VDC)

Size

See sketch
Volume: 28 ft^3 (41 ft^3 envelope)

Weight

Machine weight:	5,570 lbs
Mount weight:	500 lbs
Total weight:	6,070 lbs

Performance at Design Point:

Power Input: 5,000 hp (3,728 kw)

Losses:	Ohmic (ac)	80.3 kw
	Friction and windage	7.1 kw
	Ohmic (rectifiers)	41.8 kw
		129 kw

Power Output: 3,599 kw
Current: 23,650 amps-dc
Voltage: 152 volts-dc Efficiency: 96.5%

Note: ac efficiency (without rectifiers) = 97.6%

Figure B-4

rectifiers. Under the contract previously cited, three designs were developed with the following characteristics for the ac portion of the machines:

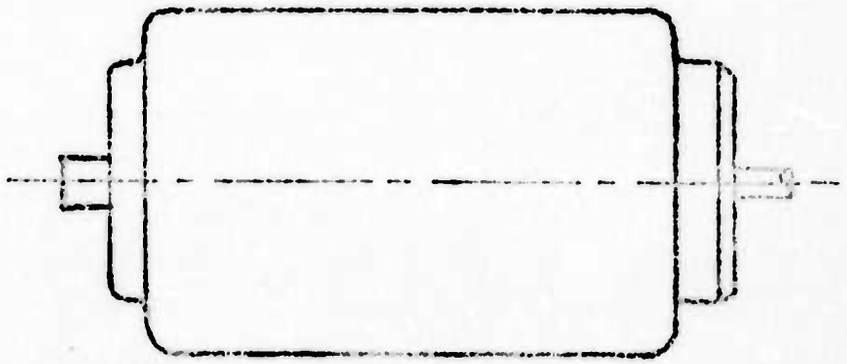
Power	OD	Length	Weight	Speed	ac Efficiency
3,000 hp	18"	43"	1,900 lbs	10,000 rpm	97.2%
5,000 hp	24"	61"	4,950 lbs	7,200 rpm	97.6%
20,000 hp	50"	84"	19,600 lbs	3,600 rpm	98.4%

The crossover alternator for this application must be capable of handling 10,000 hp when either one or three main turbines are used to power the two propellor shafts. The design data for the three machines above was extrapolated to arrive at the following specifications for the required alternator:

Power	OD	Length	Weight	Speed	ac Efficiency
10,000 hp	36"	72"	10,000 lbs	5,000 rpm	98.0%

The 98% efficiency is considered a conservative estimate in view of the fact that the original designs were constrained by the necessity of limiting voltages because of the rectifier bank in the ac-dc versions; with these limitations removed, efficiency greater than 98% should be possible. The 98% value was used in the study and a value of 96% efficiency was used for a pair of alternators for crossover. Essential details of the alternator are shown in figure B-5.

10,000 HP AC ALTERNATOR



Design Point:

10,000 hp at 5,000 rpm
(7,450 kw @ 4,160 vac)

Size

OD: 3.0 ft
Length: 6.0 ft
Volume: 42.4 ft^3

Weight:

Machine weight: 10,000 lbs
Mount weight: 1,000 lbs
Total weight: 11,000 lbs

Performance at Design Point:

Power input: 10,000 hp (7457 kw)
Losses: 149 kw (est.)
Power output: 7,308 kw (8,416 kva)
Current: 2,029 amps
Voltage: 4,160 volts Efficiency: 98.0%

Figure B-5

B.6 TRANSMISSION LINES

Varying the transmission line resistances vs. performance over the mission profile provided the following relationship for the baseline configuration:

Fuel consumed due to line resistances (in lbs/hr),

$$W_F = 0.76\ R_T + 0.98\ R_{MG} + 0.22\ R_C \text{ (Main Turbines only)}$$

$$= 0.69\ R_T + 0.80\ R_{MC} + 0.20\ R_C + 0.14 R_{CC} \text{ (Main + Cruise Turbines)}$$

Where:

R_T = Motor transmission line resistance

R_{MC} = Main generator buss line resistance

R_{CG} = Cruise generator buss line resistance

R_C = Crossover line resistance

(All in micro-ohms)

Taking the transmission lines as coaxial aluminum tubes with integral fluid cooling tubes, the cross-sectional area required for the aluminum and the cooling tubes is:

Aluminum: $53.76 \frac{L}{R}$ (in^2)

Coolant: $2.663 \times 10^{-11}\ I^2 R$ (in^2)

Where:

L = Length (ft)

R = Resistance (micro-ohms)

I = Maximum design current (amps)

An additional 20% is allowed for coolant pipe and insulation thickness. The total weight of the transmission line is:

$$W_L = \frac{48.56}{R} \cdot L^2 + 1.385 \times 10^{-11} I^2 R \cdot L \text{ (lbs)}$$

A trade-off thus occurs between the transmission line weights and the weight of fuel consumed, as shown in figure B-6.

The transmission line weights were optimized against the amount of fuel burned in 500 hours with the following results:

- Baseline configuration
  - Motor transmission lines(2): 17 μΩ, 32' long, 3000 lbs each.
  - Main generator buss lines: 9 μΩ each, 55' total, 4190 lbs total.
  - Fwd cruise generator line: 85 μΩ, 82', 4000 lbs.
  - Aft cruise generator line: 72 μΩ, 52', 1910 lbs.
  - Crossover line: 110 μΩ, 157', 11200 lbs.
- Reconfigured Engine Room Version
  - Motor transmission lines(2): 62 μΩ each; fwd. line 132', 10100 lbs; aft line 44'; 1890 lbs.
  - Main generator buss lines: 10 μΩ, 72' total, 5660 lbs total.
  - Fwd cruise generator line: 97 μΩ, 98', 5000 lbs.
  - Aft cruise generator line: 100 μΩ, 71', 2630 lbs.
  - Crossover line: 27 μΩ, 41', 3030 lbs.

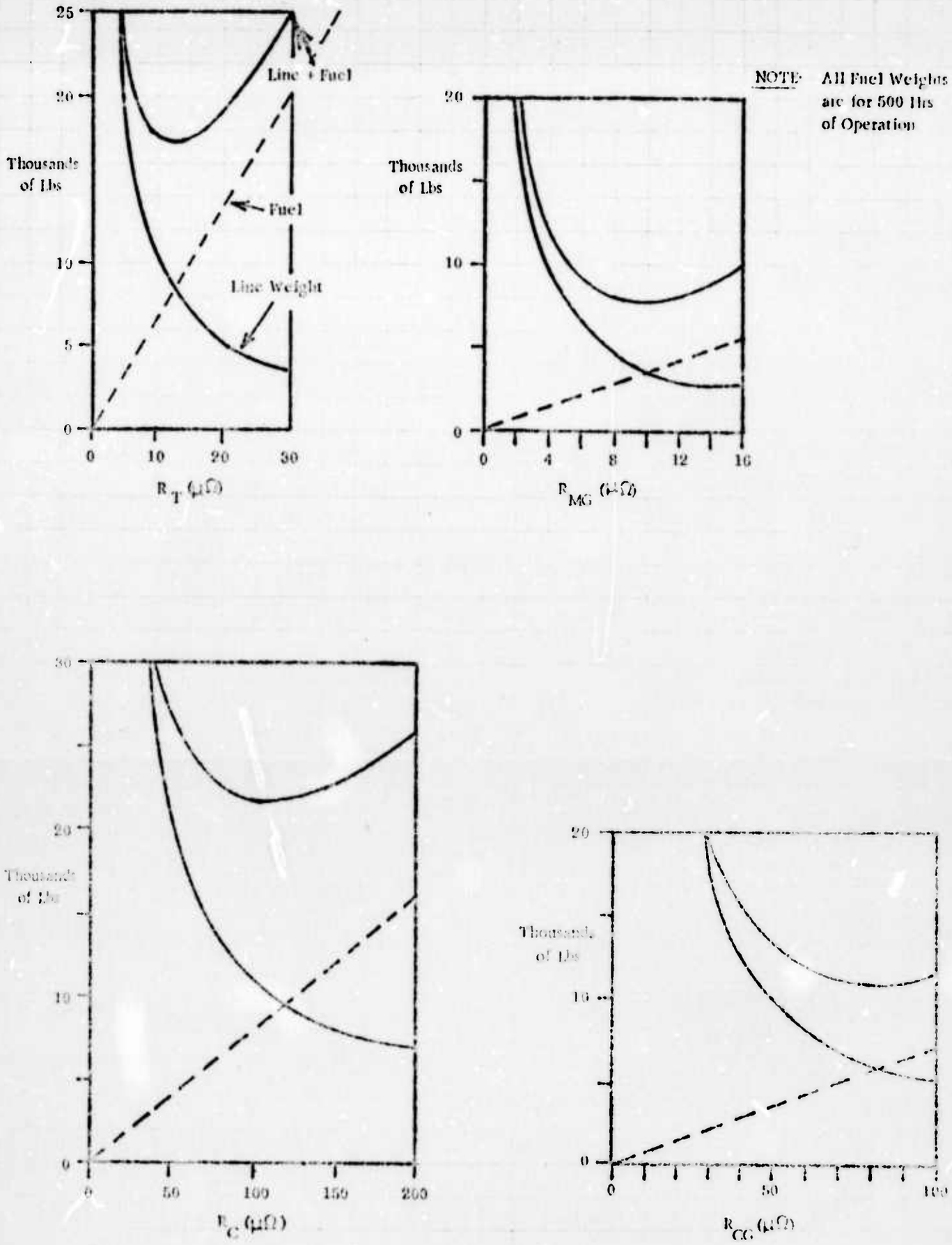


Figure B-6. Line and Fuel Rates vs. Resistances

The actual configurations are shown in figure B-7. As may be seen, the total resistance between motors and generators differs for each combination selected. In order to simplify analysis, a set of equivalent resistances were computed which would give the same ohmic (I^2R) loss as the actual physical configuration, but which would permit a single motor transmission line resistance to be used between the motors and a common buss point. Each generator is then considered to be connected to this common point with a resistance which is the same as that for each of the other generators. The resultant values are [1]:

Baseline Configuration	Reconfigured Engine Room
$R_T = 17$	55
$R_1 = 94.3$	98.7
$R_2 = 77.0$	107
$R_3 = 33.6$	8.72
$R_4 = 9.0$	17.0
$R_5 = 18.0$	3.59
$R_6 = 9.0$	17.0

where:

R_T is resistance between motor and buss point

R_1 is for 1 cruise turbine

R_2 is for 2 cruise turbines

R_3 is for 1 main turbine

R_4 is for 2 main turbines

R_5 is for 3 main turbines

R_6 is for 4 main turbines

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(1) All values in micro-ohms.

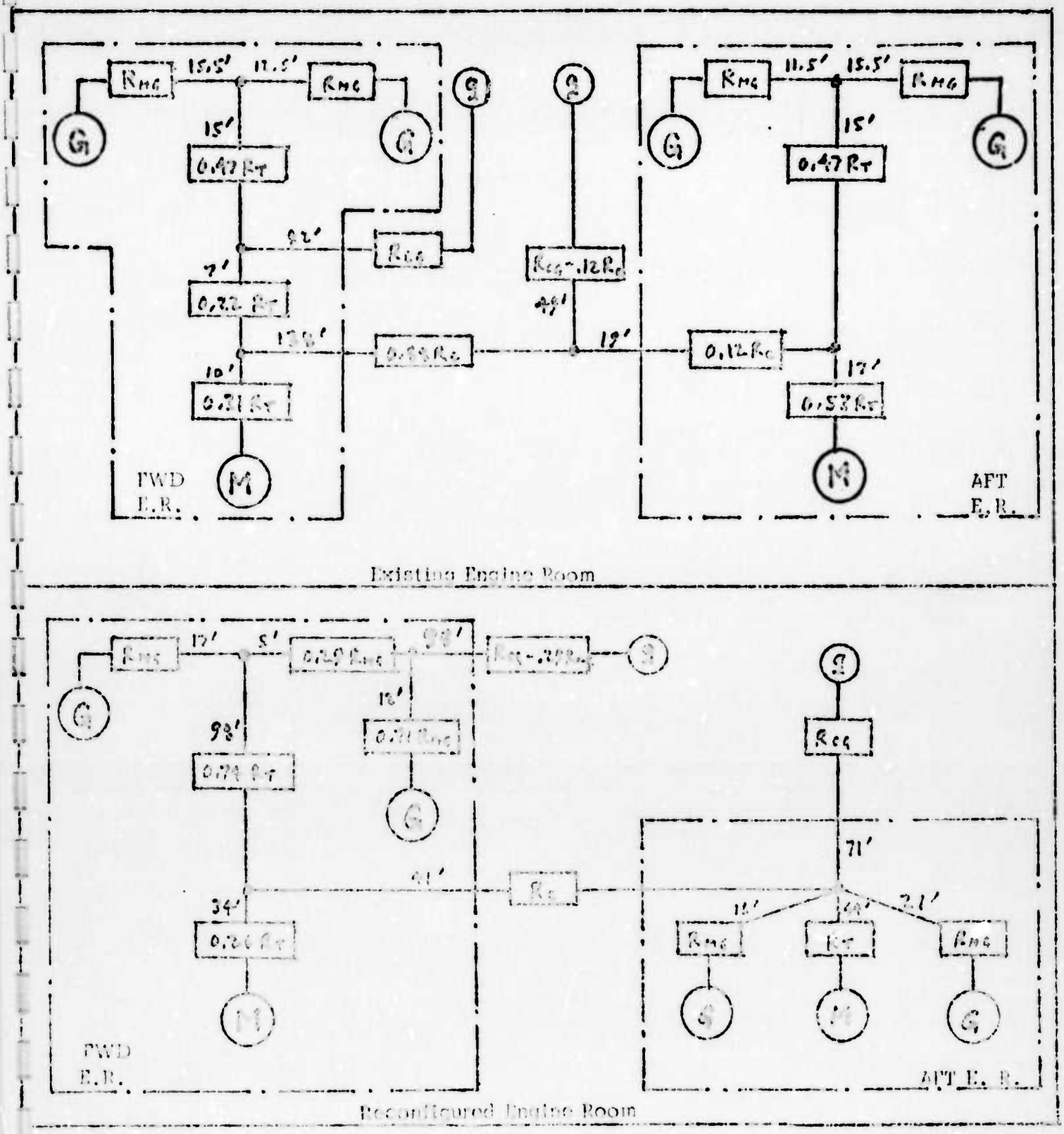

Figure B-7. Transmission Line Configurations

For cruise turbines located in the engine rooms, instead of topside, the transmission lines were assumed to be 20 ft/ long with a resistance of 27 micro-ohms each and a weight of 1500 lbs. for the pair. The values for R_T and R_3 through R_6 remain the same as for the reconfigured engine room case; R_1 and R_2 become:

$$R_1 = 18.72\ \mu\Omega$$

$$R_2 = 27.00\ \mu\Omega$$

B.7 HELIUM COMPRESSORS

Based on the estimated motor and generator helium losses, the amount of compressor power required for each was estimated as follows:

Machine	Helium Loss	Carnot Power Required to Reliquify	Compressor Power Required
Motor	0.097 gm/sec	0.694 Kw	22.8 Kw
Main Generator	0.045 gm/sec	0.322 Kw	12.8 Kw
Cruise Generator	0.046 gm/sec	0.329 Kw	13.0 Kw

Assuming one compressor per engine room, the total compressor power required is:

Main Turbines Only:	48.4 Kw
Main + Cruise Turbines:	61.4 Kw

The compressor sizes required for these outputs were estimated at:

	Main Turbines Only	Main + Cruise Turbines
Maximum Power	50 Kw	65 Kw
Volume	33 ft^3	43 ft^3
Weight	2500 lbs	3250 lbs
Length	7 ft	7 ft
Diameter	2.5 ft	2.8 ft

B.8 HELIUM CRYOSECTIONS

Helium cryosections are mounted adjacent to each superconducting machine and form the final refrigeration (expansion) stage. All cryosections were kept the same size for commonality, being sized to handle a maximum

load of 0.10 gm/sec of helium. Two cryosections are used per motor to facilitate rapid cooldown and to provide redundancy in case of failure. The generators have one cryosection each which normally operate at half capacity except during initial cooldown. Each cryosection is 2.0 ft. in diameter by 5.0 ft. long and weights 933 lbs.

B.9 HELIUM CRYOLINES

The cryogenic transfer lines between the compressors and cryosection were designed to handle the maximum load, based on the number of cryosections used. Line sizes and weights required are as follows:

Number of Cryosections	Line OD	Weight (lbs/ft)
1	2.0"	2.28
2	2.9"	4.56
3	3.5"	6.84
4	4.1"	9.12
5	4.6"	11.40

The total length of lines and total weight for each configuration is:

	Baseline Configuration	Reconfigured Engine Room
Fwd. Engine Room	46 ft; 232 lbs	140 ft; 752 lbs
Fwd. Cruise Turbine	80 ft; 184 lbs	70 ft; 175 lbs
Aft Engine Room	56 ft; 243 lbs	54 ft; 322 lbs
Aft Cruise Turbine	60 ft; 138 lbs	60 ft; 150 lbs

B.10 SWITCHGEAR

Based on designs developed at NSRDC, Annapolis, the sizes and weights for electrical switches required were estimated as follows:

For Use With	Size	Weight
Cruise Generator	15" x 21" x 5"	85 lbs each
Main Generator	21" x 30" x 7"	275 lbs each
Crossover Line	17" x 26" x 5"	135 lbs each

The switches have been designed to handle the maximum currents + transients which occur in each application and serve to connect and disconnect the generators from the buss line, reverse generator polarities and to open and close the crossover line. In adition to the switches, rheostats are required so that voltages can be matched when bringing generators on and off line, when switching in crossover and when reversing the motors. The rheostats required were estimated as follows:

For Use With	Size	Weight
Cruise Generator	29" x 20" x 24"	740 lbs
Main Generator	40" x 40" x 48"	4000 lbs
Crossover Line	29" x 26" x 24"	770 lbs

For each application, four switches and one rheostat are required in order to provide forward/reverse polarities and disconnect. The total switchgear units resulting are packaged as follows:

For Use With	Size	Weight
Cruise Generator	24" x 30" x 41"	1100 lbs each
Main Generator	40" x 48" x 70"	5100 lbs each
Crossover Line	24" x 32" x 46"	1300 lbs each

B.11 ESTIMATE OF SHIPS SERVICE POWER

Based on trends in electric power capacity aboard DD class vessels as follows:[1]

Year	Kw Power
1945	1,000
1955	2,000
1975	6,000

an installed capacity of 6,000 Kw was assumed. A steady load of 4,000 Kw was then assumed for assessing impact on ship's range (parametric variations in the study allow adjustment for changes in this power level).

A level of 4,000 Kw can be provided by one nominally 5000 hp turbine operating at near full load; fuel load would be 2700 lbs/hr. If a second, standby, turbine is assumed to be operating at all times at an idel fuel load of 360 lbs/hr, the total fuel load is 3060 lbs/hr for 4000 kw output, or 0.77 lb/Kw-hr. Based on this, the ships auxiliary generator fuel rate was assumed to be 0.8 lb/Kw-hr.

(1) C. Graham, "Factors Affecting Naval Ship Design", Naval Engineers Journal, February, 1972, p.85.

APPENDIX C - COMPUTER STUDIES

C.1 GENERAL

This appendix contains a general discussion of the computer program utilized for analysis of the various propulsion configurations over the mission profile and output data sheets for the most important cases.

Math models for the turbines, propellers, drag, electric motors and generators and electrical transmission lines which were incorporated into the computer program are detailed in Appendix A.

Electric drive system losses were analyzed based on the motor, generator and transmission line models. Geared drives were analyzed by assuming a fixed gear efficiency for the main reduction gears and shafting losses[1] and a fixed efficiency for the crossover alternators[2] and turbine horsepower required at each speed was obtained by dividing shaft horsepower by the efficiency.

Cooling loads were computed based on an estimated 0.02 kw of ship service load per hp lost in the transmission system and 0.8 lbs/kwh was used as the ship service auxiliary generator fuel rate. For the electrical

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(1) 0.960 efficiency was used in the study.

(2) 0.980 efficiency per alternator, or 0.960 for the pair was used.

systems, 1 kw of power was added for each generator in use for lubrication pump power (motor lubrication was assumed to be an equal trade-off for the main reduction gear lube load). Constant helium compressor powers were used through the electrical drive missions[1].

[1] 100 kw for main turbines only; 130 kw for main and cruise turbine configurations.

C.2 COMPUTER PROGRAM

The math model computer program consists of a main program and four subprograms:

- PITCH
- GENM
- MISSN
- ROUND

The function of each is as follows:

MAIN PROGRAM

- Reads calculation limits and performance (speed and configuration) requirements.
- Obtains fuel rate from PITCH for given pitch ratio.
- Optimizes pitch, if pitch is not fixed, by a search procedure; fuel rate is obtained from PITCH for each pitch ratio until minimum fuel is obtained. Four different search procedures are utilized:
  - Fibonacci search for minimum fuel (used for electric drive).
  - Interval search for minimum fuel (used for geared drive.)
  - Interval search for fuel rate equal to turbine idle rate (used for geared drive under low power condition).
  - Pitch is fixed for electric drives when fuel rate drops below the idle rate.

- Increases number of turbines when the fuel rate exceeds the maximum allowed with the existing configuration.
- When cruise turbines are used, compares results for main turbines and uses the most efficient.
- Calculates and prints final results for each speed.
- Passes final result for each speed to MISSN and calls for summary when last speed is reached (last speed for which turbine configuration specified can attain results within allowed fuel and turbine speed limitations).
- Reads new performance requirements when summary is complete.
- Reads in new or changed specification data (gear ratios, electric constants, etc.) when called for.

PITCH Subprogram

- Reads propeller and drag constants.
- For geared drive, reads gear ratios, efficiencies and turbine constants.
- For electric drive, reads motor constants and transmission line resistances.
- Computes drag, propeller and turbine characteristics.
- Computes turbine fuel when supplied with propeller pitch from MAIN (calculated directly for geared drive; for electric drive,

motor/propeller speed and torque are computed, voltages and currents are computed and required generator voltage and current are passed to GENM, which returns fuel rate).

GENM Subprogram (used for electric drive only)

- Reads generator and turbine constants.
- Computes turbine idle characteristics.
- Computes fuel rate when supplied with generator voltage and current.
  - .. If magnet field is not fixed, the optimum turbine speed is computed and the field is adjusted to match this field.
  - .. If the field is fixed, the corresponding speed and fuel rate are computed.
  - .. If fuel drops below the minimum turbine (idle) fuel rate, the magnet field is reduced until fuel rate equals idle unless no field change is allowed.
- "Flags" the result if maximum turbine speed is exceeded or fuel rate is above or below the allowable fuel rate.

MISSN Subprogram

- Reads mission profile (percent time at each speed).
- Receives ship speed, turbine configuration, propeller speed, horsepower (turbine, shaft and effective), pitch ratio, effective

gear ratio, turbine fuel rate, turbine figure of merit, refrigeration load and lubrication load from PITCH.

- Selects values corresponding to smallest fuel rate when more than two sets of data are received at the same speed.
- Computes miles/ton of turbine fuel, and, per thousand hours: miles, tons of fuel and total propulsion system (turbines plus electric system load) tons/mile. Prints results for each speed.
- Computes and prints average results over mission profile.
- Calls ROUND to round results to specified accuracy before printing.

ROUND Subprogram

- Rounds data to accuracy called for in input. For example, if 4-place accuracy is specified, 35693.1 becomes 35690.0; 21.2195 becomes 21.2200, etc.

Program Variables

The program has the following variables as inputs, independent of the specific configuration being investigated:

Overall Limits

- Required accuracy in fuel rate.
- Required accuracy in P/D ratio.
- Number of iterations allowed in search for minimum fuel.
- Maximum allowable P/D rato.

Drag Calculations

- 3 Drag coefficients (C_{D0}, V_X and C_2)

Propellers

- Propeller diameter
- Water density
- 6 thrust coefficients (T_{01}, T_{02}, etc.)
- 7 torque coefficients (Q_{01}, Q_{02}, etc.)

Turbines (Main and Cruise)

- 4 Turbine fuel constants (W_1, W_2, W_3 and W_4).
- Minimum fuel rates.
- Maximum fuel rates.
- Maximum rpms.

Geared Drive

- Main gear ratio
- Cruise gear ratio
- Gear efficiency
- Alternator efficiency

Electric Drive

- Refrigeration power requirements
- Lubrication power requirements
- Magnet field (fixed or variable)

- 5 Motor constants (K_{FM}, K_{EM}, K_{VM}, K_M and R_M)
- 5 Generator constants (K_{FG}, K_{EG}, K_{VG}, K_G and R_G) (both cruise and main)
- 7 Resistances (R_T and R_{B1} - R_{B6})

Mission Profile

- Percent time at each speed

For each configuration run, the following variables are input:

Speed

- Minimum speed.
- Maximum speed.
- Increments in speed (between minimum and maximum speeds specified).
- Minimum number of turbines and type.
- Maximum number of turbines and type.
- Odd number of turbines allowed or not allowed (i.e., crossover or no crossover).
- P/D ratio (fixed or variable).
- Percent magnet field (fixed or variable) (electric drive only).
- Number of digits accuracy desired in final printout.
- Magnet field adjustment allowed or not allowed (electric drive only).

In addition:

- A punch card record of results for each speed may be called for.[1]
- Step-by-step details of each search procedure may be called for.
- The search calculation made may be changed (between Fibonacci and interval search).

(1) Cards may be used as input to an existing mission analysis program which gives details of performance of each system component at each speed and may be run over different mission profiles.

C.3 COMPUTER RESULTS

This section contains results of the computer runs for various configurations and variations.

Included are:

- Program constants used for the geared drive systems (Ref. No. 101).
- Program constants used for the electric drive systems (baseline configuration, ref. no. 1; reconfigured engine room, ref. no. 2 and optimum configuration[1], ref. no. 3).
- Propeller performance, ship drag and mission profile.
- Mission profile summaries[2] for the baseline, baseline + alternators, baseline + cruise turbines and baseline + alternators and cruise turbines configurations.
- Mission profile summaries for the electric drive systems (baseline configuration, reconfigured engine room for the systems with and without cruise turbines and optimum configuration for the system with cruise turbines.

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(1) Cruise turbines moved to engine room.

(2) "RANGE" is the range based on turbine fuel rate only; "TONS OF FUEL AND TONS PER MILE" include the impact of cooling, lube system and helium compressor loads. "SPEED RATIO" is the ratio of turbine speed to propeller rpms. "REF. NO." refers to the program constants.

- Mission Profile Summaries for the geared and electric configurations with variable (fully optimized) pitches.

- Mission Profile Summaries for the electric drive baseline configurations with the generator fields fixed (at 90%), fixed to the nearest 10% and fixed at "optimum" settings.[1]

- Mission Profile Summaries for each turbine (1 cruise, 2 cruise, 1 main, etc.) for the baseline configuration electric drive; included for these summaries is a second page for each giving details of propellor, turbine and drive efficiencies, percent magnet field, voltages and currents.

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(1) 90% for cruise turbines
60% for one main turbine
75% for two main turbines
90% for three and four main turbines

ADVANCED DESTROYER FUEL OPTIMIZATION... REF.NO. 101

UNDER LOW POWER CONDITIONS A FUEL RATE WITHIN 0.010 LBS/HR OF WMIN IS SOUGHT
.....A MAXIMUM OF 20 ITERATIONS ARE ALLOWED

FOR HIGHER POWER CONDITIONS A SEARCH ROUTINE IS USED TO FIND THE MINIMUM FUEL RATE TO WITHIN 0.0030 CHANGE IN THE P/D RATIO .....
OR UNTIL THE FUEL RATE CHANGES BY LESS THAN 0.010 LBS/HR

THE MAX. ALLOWABLE P/D RATIO IS 2.0000

THE PROGRAM RUN IS TERMINATED IF MORE THAN 700 VALUES OF SHIPS SPEED ARE ENCOUNTERED

PROGRAM CONSTANTS

MAIN GEAR RATIO= 21.50 CRUISE GEAR RATIO= 74.00
GEAR EFFICIENCY= 0.960
ALTERNATOR EFFICIENCY= 0.9600
DRAG COEFFICIENTS...CDO=1.4000 VX=27.00 C2=5.0000

WATER DENSITY=1.9905

PROPELLOR DIAMETER=17.00

THRUST COEFFICIENTS...
TQ1= 0.0500 TQ2= 1.0130 TQ3= 0.0060
TV1=-0.2600 TV2= 1.0000 TV3=-0.1000

TORQUE COEFFICIENTS...
CQ1= 0.4550 CQ2= 0.5470 CQ3= 0.1577
CV1= 0.1830 CV2= 0.1633 CV3= 1.5140 BX=1.4250

CRUISE TURBINE CONSTANTS...W1= 750.00 W2= 0.040
W3= 0.3300 W4=.13005-03

WMIN= 360.0 RPM
WMAX= 2700.0 RPM
SMAX= 7200.0 RPM

MAX. POWER = 5715.00 HP AT 7238.21 RPM (2.117 HP/LB/HR)

MAIN TURBINE CONSTANTS...W1= 5600.00 W2= 1.050
W3= 0.1430 W4=.11435-02

WMIN= 1100.0 RPM
WMAX= 8400.0 RPM
SMAX= 3600.0 RPM

MAX. POWER = 22024.04 HP AT 3295.46 RPM (2.622 HP/LB/HR)

ELECTRIC DRIVE ID NUMBER 2

MOTOR CONSTANTS...
KFM= 0.66810E-04
KFM= 0.18270E-02
KVM= 0.68590E-07
KM= 0.16328E 01
AM= 0.60000E-04

TRANSMISSION CONSTANTS
RT= 0.17000E-04
RR(1)= 0.94280E-04 RR(2)= 0.77030E-04
RR(3)= 0.34500E-04 RR(4)= 0.90000E-05
RR(5)= 0.17950E-04 RR(6)= 0.90000E-05

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

MAIN GENERATOR CONSTANTS..KF=0.16365E-05
KF=0.25530E-05
KV=0.86820E-09
KC=0.91100E-01
RG=0.11200E-04

TURBINE CONSTANTS..W1=6600.000
W2= 1.050
W3= 9.143
W4= 0.11+3E-02
WMIN= 1100.0 PPH
WMAX= 6400.0 PPH
SMAX= 6600.0

IDLE POWER= 16.49 HP AT 1+72.91 RPM
IDLE FUEL= 1100.00 PPH FUEL... 134.18 VOLTS AT TERMINALS
MAX POWER= 22024.06 HP AT 3295.46 RPM (2.622 HP/LB/HR)

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

CRUISE GENERATOR CONSTANTS..KF=0.173b0E-05
KF=0.5790DF-07
KV=0.4827bF-11
KC=0.209000F-01
RG=0.24000E-04

TURBINE CONSTANTS..W1= 750.000
W2= 0.060
W3= 3.390
W4= 0.1900E-03
WMIN= 300.0 PPH
WMAX= 2700.0 PPH
SMAX= 7200.0

IDLE POWER= 4.09 HP AT 3502.45 RPM
IDLE FUEL= 360.00 PPH FUEL... 73.20 VOLTS AT TERMINALS
MAX POWER= 5715.90 HP AT 7736.21 RPM (2.117 HP/LB/HR)

REFRIGERATION POWER= 100.00 KW FOR MAIN GENERATORS ONLY AND 130.00 KW FOR MAIN + CRUISE GENERATORS

TURF POWER= 1.00 KW PER GENERATOR

DRAG COEFFICIENTS....CD0=1.4000 VX=27.00 C2=5.0000

WATER DENSITY=1.9905

PROPELLOR DIAMETER=17.00

THRUST COEFFICIENTS...
T01= 0.0500 T02= 1.0130 T03= 0.0060
TM1=-0.2600 TM2= 1.0000 TM3=-0.1600

TORQUE COEFFICIENTS...
Q01= 0.4550 Q02= 0.5470 Q03= 0.1577
QM1= 0.1830 QM2= 0.1[illegible]3 QM3= 1.5180 KA=1.4250

C-13

ELECTRIC DRIVE ID NUMBER 2

REF. NO. 32

MOTOR CONSTANTS...
KF4= 0.648108E-04
KP4= 0.107708E-02
KV4= 0.685908E-07
KM= 0.163288E 01
RM= 0.600008E-04

TRANSMISSION CONSTANTS
RT= 0.955008E-04
RR(1)= 0.587208E-04 RR(2)= 0.107008E-03
RR(3)= 0.877208E-05 RR(4)= 0.175008E-04
RR(5)= 0.359408E-05 RR(6)= 0.176008E-04

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

MAIN GENERATOR CONSTANTS..KF=0.183608E-05
KF=0.255108E-05
KV=0.868208E-09
KQ=0.911008E-01
RG=0.112008E-04

TURBINE CONSTANTS..w1=5600.000
w2= 1.050
w3= 7.143
w4= 0.1143E-02
WMIN= 1100.0 PPH
WMAX= 8400.0 PPH
SMAX= 3600.0

IDLE POWER= 16.49 HP AT 1472.91 RPM
IDLE FUEL= 1100.00 PPH FUEL... 134.15 VOLTS AT TERMINALS
MAX POWER= 22024.06 HP AT 3295.46 RPM (2.622 HP/LB/HR)

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

CRUISE GENERATOR CONSTANTS..KF=0.173608E-05
KF=0.879008E-07
KV=0.468208E-11
KQ=0.209408E-01
RG=0.240008E-04

TURBINE CONSTANTS..w1= 750.000
w2= 0.360
w3= 3.350
w4= 0.1900E-03
WMIN= 360.0 PPH
WMAX= 2700.0 PPH
SMAX= 7200.0

IDLE POWER= 4.09 HP AT 1502.45 RPM
IDLE FUEL= 360.00 PPH FUEL... 73.20 VOLTS AT TERMINALS
MAX POWER= 5715.90 HP AT 7236.21 RPM (2.117 HP/LB/HR)

A1-D

REFRIGERATION POWER= 100.00 KW FOR MAIN GENERATORS ONLY AND 130.00 KW FOR MAIN + CRUISE GENERATORS

IDLE POWER= 1.00 KW PER GENERATOR

DRAG COEFFICIENTS....CD0=1.4000 VX=27.00 C2=5.0000

WATER DENSITY=1.9905

PROPELLOR DIAMETER=17.00

THRUST COEFFICIENTS...
TC1= 0.0500 TC2= 1.0130 TC3= 0.0060
TM1=-0.2600 TM2= 1.0000 TM3=-0.1800

TORQUE COEFFICIENTS...
CQ1= 0.4550 CQ2= 0.5470 CQ3= 0.1577
CM1= 0.1630 CM2= 0.1633 CM3= 1.5160 KA=1.4250

ELECTRIC DRIVE ID NUMBER 2

MOTOR CONSTANTS...
KFM= 0.64810E-04
KFM= 0.18270E-02
KVM= 0.68590E-07
KM= 0.16326E 01
RM= 0.60000E-04

TRANSMISSION CONSTANTS
RT= 0.35000E-04
RR(1)= 0.13720E-04 RR(2)= 0.27000E-04
RR(3)= 0.87200E-05 RR(4)= 0.17000E-04
RR(5)= 0.45400E-05 RR(6)= 0.17000E-04

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

MAIN GENERATOR CONSTANTS..KF=0.16306E-05
KF=0.7553[illegible]E-05
KV=0.[illegible]E-09
RG=0.[illegible]E-01
RA=0.[illegible]E-04

TURBINE CONSTANTS..W1=6600.000
W2= 1.050
W3= 9.140
W4= 0.1143E-02
WMIN= 1100.0 PPH
WMAX= 6400.0 PPH
SMAX= 3600.0

IDLE POWER= 16.49 HP AT 1472.91 RPM
IDLE FUEL= 1100.00 PPH FUEL... 134.18 VOLTS AT TERMINALS
MAX POWER= 2202[illegible].06 HP AT 3245.46 RPM (2.622 HP/LB/HR)

VALUES GIVEN BELOW ARE FOR 100 PERCENT GENERATOR FIELD

CRUISE GENERATOR CONSTANTS..KF=0.17[illegible]E-06
KF=0.5790[illegible]E-07
KV=0.48[illegible]E-11
RG=0.20[illegible]E-01
RA=0.24[illegible]E-04

TURBINE CONSTANTS..W1= 750.000
W2= 0.360
W3= 3.350
W4= 0.1700E-03
WMIN= 360.0 PPH
WMAX= 2700.0 PPH
SMAX= 7200.0

IDLE POWER= 4.[illegible] HP AT 3502.45 RPM
IDLE FUEL= 360.0[illegible] PPH FUEL... 73.20 VOLTS AT TERMINALS
MAX POWER= 5715.[illegible] HP AT 7258.21 RPM (2.117 HP/LB/HR)

REFRIGERATION POWER= 100.00 KW FOR MAIN GENERATORS ONLY AND 130.00 KW FOR MAIN + CRUISE GENERATORS

TURB POWER= 1.00 KW PER GENERATOR

DRAG COEFFICIENTS....CDO=1.4000 DX=27.00 D2=5.0000

WATER DENSITY=1.9905

PROPELLOR DIAMETER=17.00

THRUST COEFFICIENTS...
TO1= 0.0500 TO2= 1.0130 TO3= 0.0000
TM1=-0.2600 TM2= 1.0000 TM3=-0.1500

TORQUE COEFFICIENTS...
QO1= 0.4550 QO2= 0.5470 QO3= 0.1977
QM1= 0.1830 QM2= 0.1633 QM3= 1.5160 RX=1.4250

C-45

PROPELLOR PERFORMANCE DATA..

P/D RATIO	KQ J=0... CT=	CQ=	VALUE OF J FOR.... CT=0	CQ=0	MAX.EFFCY	MAX.EFFCY (PERCENT)
0.2735	0.000000	0.022818	0.0000	0.6154	0.1944	0.00
0.3000	0.002380	0.021118	0.0564	0.6131	0.2131	2.09
0.4000	0.011200	0.016038	0.4062	0.6000	0.3370	16.70
0.5000	0.018500	0.012701	0.5000	0.5978	0.3666	23.22
0.6000	0.023500	0.009168	0.6001	0.5400	0.4011	42.25
0.7000	0.028100	0.007353	0.7000	0.5151	0.5408	57.26
0.8000	0.032400	0.005841	0.8000	0.5000	0.6301	62.63
0.9000	0.036420	0.004677	0.9000	1.0150	0.7335	64.92
1.0000	0.040100	0.003682	1.0000	1.1701	0.8356	65.82
1.1000	0.043820	0.002976	1.1016	1.2975	0.9367	66.57
1.2000	0.047000	0.002357	1.2000	1.3995	1.0352	70.37
1.3000	0.050300	0.001924	1.3000	1.4924	1.1304	71.03
1.4000	0.053300	0.001601	1.4000	1.5808	1.2235	75.25
1.5000	0.056500	0.001353	1.5000	1.6703	1.3026	76.21
1.6000	0.059200	0.001182	1.6000	1.7503	1.4460	76.06
1.7000	0.061900	0.001012	1.7000	1.8407	1.5336	77.24
1.8000	0.064600	0.000892	1.8000	1.9205	1.6130	77.46
1.9000	0.067000	0.000787	1.9000	2.0010	1.6911	77.64
2.0000	1.000000	0.000700	2.1000	2.1700	1.7627	77.00

SHIP DRAG DATA... EFF. NO. 101

SPEED (KTS)	DRAG (LBS)	EFFECTIVE HP
1.0	456.	1.40
2.0	1824.	11.20
3.0	4103.	37.70
4.0	7295.	89.60
5.0	11399.	175.00
6.0	16413.	302.50
7.0	22340.	480.20
8.0	29177.	714.30
9.0	36930.	1020.60
10.0	45599.	1403.00
11.0	55186.	1867.40
12.0	65693.	2419.20
13.0	77121.	3063.80
14.0	89469.	3806.60
15.0	102738.	4650.00
16.0	116928.	5594.60
17.0	132041.	6643.10
18.0	148076.	7796.70
19.0	165033.	9060.80
20.0	182913.	11438.00
21.0	201716.	12730.10
22.0	221441.	14037.10
23.0	242089.	17359.70
24.0	263661.	19053.50
25.0	286156.	21074.00
26.0	309574.	24424.10
27.0	333916.	27504.10
28.0	359181.	32120.20
29.0	385369.	37249.61
30.0	412482.	42914.40
31.0	440517.	49120.80
32.0	469476.	56701.21
33.0	499358.	64877.13
34.0	530163.	73731.63
35.0	561890.	81988.19
36.0	594540.	92033.44

MISSION PROFILE TIME PERCENTAGES FOR 1-10,11-20,21-30 AND 31-40 KNOTS....

1.10	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
6.30	6.70	7.00	7.10	6.80	6.10	4.40	7.20	7.20	8.80
7.50	4.30	1.50	1.30	0.70	0.30	0.40	0.30	0.30	0.30
0.30	0.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

91 - D.

GEARED DRIVE SYSTEM

REF.NO. 101

MISSION PROFILE SUMMARY - BASELINE CONFIGURATION

KTS	PCT. TIME	P/C RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	0.278	44.09	21.50	1.40	440.20	458.60	2200.	1.018	11.	10.81	0.982	2 MAIN
2	1.00	0.335	47.58	21.50	11.00	410.20	427.30	2200.	2.036	24.	11.79	0.491	2 MAIN
3	1.20	0.378	50.73	21.50	37.00	374.50	390.10	2200.	3.055	36.	11.79	0.327	2 MAIN
4	1.20	0.487	53.03	21.50	80.00	366.40	381.70	2200.	4.073	48.	11.79	0.246	2 MAIN
5	1.20	0.646	50.07	21.50	176.00	302.10	360.00	2000.	5.001	60.	11.99	0.196	2 MAIN
6	1.20	0.867	42.35	21.50	302.40	451.50	470.30	2000.	6.109	72.	11.79	0.164	2 MAIN
7	1.20	1.200	41.34	21.50	480.00	666.00	693.50	2350.	6.647	84.	12.64	0.150	2 MAIN
8	1.20	1.200	47.25	21.50	716.00	595.30	1037.00	2007.	6.912	96.	13.82	0.145	2 MAIN
9	1.20	1.700	53.15	21.50	1021.00	1417.00	1476.00	2056.	7.059	108.	15.31	0.142	2 MAIN
10	1.00	1.800	59.06	21.50	1400.00	1744.00	2005.00	2150.	7.107	120.	16.88	0.141	2 MAIN
11	6.80	1.400	64.06	21.50	1963.00	2707.00	2845.00	2361.	7.076	492.	69.54	0.141	2 MAIN
12	6.70	1.200	70.69	21.50	2610.00	3355.00	3465.00	2565.	6.939	804.	115.90	0.144	2 MAIN
13	7.00	1.200	78.07	21.50	3376.00	4271.00	4409.00	4265.	6.656	910.	137.00	0.146	2 MAIN
14	7.10	1.200	82.68	21.50	3842.00	5334.00	5506.00	4600.	6.667	994.	149.00	0.150	2 MAIN
15	6.90	1.200	88.59	21.50	4705.00	6561.00	6774.00	5174.	6.494	1020.	157.20	0.154	2 MAIN
16	6.10	1.200	94.48	21.50	5734.00	7968.00	8224.00	5704.	6.283	976.	155.50	0.159	2 MAIN
17	6.60	1.200	100.40	21.50	6978.00	9581.00	9869.00	6282.	6.062	1122.	185.30	0.165	2 MAIN
18	7.20	1.200	106.30	21.50	8165.00	11340.00	11810.00	6810.	5.834	1296.	222.40	0.172	2 MAIN
19	7.70	1.200	112.20	21.50	9601.00	13330.00	13880.00	7324.	5.603	1462.	261.40	0.179	2 MAIN
20	8.00	1.200	118.10	21.50	11200.00	15550.00	16200.00	8036.	5.373	1760.	331.70	0.186	2 MAIN
21	7.30	1.200	124.00	21.50	12970.00	18000.00	18750.00	9144.	5.144	1575.	306.60	0.195	2 MAIN
22	4.30	1.200	129.90	21.50	14910.00	20700.00	21560.00	10220.	4.919	946.	192.60	0.204	2 MAIN
23	1.50	1.200	135.80	21.50	17030.00	23650.00	24640.00	10960.	4.698	345.	73.52	0.213	2 MAIN
24	1.40	1.200	141.72	21.50	19350.00	26870.00	27990.00	11830.	4.485	312.	69.67	0.223	2 MAIN
25	0.70	1.200	147.40	21.50	21870.00	30370.00	31640.00	12080.	4.277	175.	40.98	0.234	2 MAIN
26	0.50	1.200	153.30	21.50	24610.00	34170.00	35600.00	14080.	4.074	130.	31.96	0.246	2 MAIN
27	0.40	1.200	159.30	21.50	27560.00	38260.00	39860.00	15500.	3.879	108.	27.80	0.258	2 MAIN
28	0.30	1.500	140.00	21.50	32130.00	44600.00	46350.00	21030.	2.983	84.	28.20	0.336	4 MAIN
29	0.30	1.500	144.30	21.50	37250.00	51800.00	54050.00	23410.	2.775	87.	31.39	0.361	4 MAIN
30	0.30	1.500	152.60	21.50	42980.00	60180.00	62630.00	26040.	2.579	90.	34.95	0.388	4 MAIN
31	0.30	1.500	159.00	21.50	49380.00	69460.00	72340.00	29020.	2.393	93.	38.90	0.419	4 MAIN
32	0.30	1.500	165.40	21.50	56500.00	79800.00	83130.00	32320.	2.218	96.	43.35	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	13.76	KNOTS
EFFECTIVE POWER	7420.	HP
SHAFT POWER....	10340.	HP
TURBINE POWER..	10770.	HP
TURBINE FUEL...	6332.	LBS/HR (0.191 TONS/MILE)
PROPULSION FUEL	6399.	LBS/HR (0.181 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	0.	KW
HELIUM COMPRESSORS...	0.	KW
TOTAL LOAD..	9.	KW (6.9 LBS/HR)

GEARED DRIVE SYSTEM

REF.NO. 101

MISSION PROFILE SUMMARY - BASELINE + ALTERNATORS

KTS	PCT. TIME	P/C RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	PER THOUSAND HOURS: TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	0.262	34.16	21.50	1.40	226.30	246.20	1100.	2.034	11.	5.40	0.491	1 MAIN
2	1.20	0.331	40.48	21.50	11.20	221.30	240.30	1100.	4.077	24.	5.77	0.246	1 MAIN
3	1.20	0.436	43.48	21.50	37.80	218.30	231.30	1100.	6.109	38.	5.38	0.164	1 MAIN
4	1.20	0.603	42.34	21.50	90.60	214.80	215.70	1100.	8.195	48.	5.89	0.123	1 MAIN
5	1.20	1.100	31.78	21.50	179.00	243.00	263.10	1121.	9.977	60.	6.02	0.100	1 MAIN
6	1.20	1.100	38.04	21.51	309.40	408.80	484.90	1072.	10.560	72.	6.82	0.095	1 MAIN
7	1.20	1.100	44.38	21.51	486.20	633.60	733.30	1140.	10.820	84.	7.77	0.093	1 MAIN
8	1.20	1.100	50.72	21.50	716.80	1016.00	1100.00	1075.	10.840	96.	8.86	0.092	1 MAIN
9	1.20	1.100	57.08	21.50	1001.00	1446.00	1560.00	1067.	10.630	108.	10.12	0.094	1 MAIN
10	1.80	1.100	63.38	21.50	1339.00	1934.00	2153.00	2152.	10.410	120.	11.54	0.096	1 MAIN
11	4.30	1.100	69.73	21.50	1733.00	2460.00	2665.00	2431.	10.050	603.	60.04	0.100	1 MAIN
12	6.70	1.100	76.07	21.50	2210.00	3135.00	3390.00	2734.	9.640	894.	87.46	0.104	1 MAIN
13	7.00	1.100	82.41	21.50	2775.00	4000.00	4330.00	3351.	9.211	910.	98.87	0.109	1 MAIN
14	7.10	1.100	88.75	21.50	3431.00	5003.00	5427.00	3871.	8.782	924.	113.40	0.114	1 MAIN
15	6.80	1.100	95.09	21.51	4183.00	6230.00	7365.00	4333.	8.343	1000.	122.00	0.122	1 MAIN
16	6.10	1.100	101.40	21.50	5034.00	9126.00	8817.00	4833.	7.912	994.	137.70	0.137	1 MAIN
17	5.60	1.100	107.80	21.51	6078.00	9744.00	10580.00	5332.	7.483	1192.	159.10	0.134	1 MAIN
18	7.20	1.100	114.10	21.50	8165.00	11570.00	12550.00	5837.	7.030	1296.	184.30	0.141	1 MAIN
19	7.70	1.100	120.42	21.50	9603.00	13610.00	14760.00	6350.	6.782	1462.	216.90	0.150	1 MAIN
20	8.60	1.100	126.70	21.50	11200.00	15870.00	17200.00	7075.	6.330	1780.	281.40	0.158	1 MAIN
21	7.50	1.100	133.10	21.50	12970.00	18370.00	19930.00	7766.	5.930	1578.	266.20	0.168	1 MAIN
22	4.30	1.200	101.00	21.50	14910.00	20510.00	21360.00	10210.	4.905	946.	192.60	0.203	2 MAIN
23	1.60	1.200	107.40	21.50	17030.00	23430.00	24410.00	10960.	4.711	348.	73.34	0.210	2 MAIN
24	1.20	1.200	113.80	21.50	19330.00	26600.00	27730.00	11760.	4.503	312.	69.40	0.222	2 MAIN
25	0.70	1.200	120.50	21.50	21870.00	30090.00	31350.00	13550.	4.300	176.	40.76	0.232	2 MAIN
26	0.50	1.200	144.00	21.50	24610.00	33850.00	35260.00	14190.	4.105	130.	31.72	0.244	2 MAIN
27	0.40	1.300	149.60	21.50	27560.00	37910.00	39480.00	15450.	3.916	108.	27.63	0.256	2 MAIN
28	0.30	1.400	147.40	21.50	32170.00	44240.00	48110.00	19240.	3.162	84.	26.65	0.317	3 MAIN
29	0.30	1.400	154.10	21.50	37050.00	51660.00	54050.00	22740.	2.921	87.	29.83	0.343	3 MAIN
30	0.30	1.400	160.70	21.50	42330.00	58270.00	64370.00	24020.	2.696	90.	33.43	0.372	3 MAIN
31	0.30	1.500	159.00	21.50	48000.00	66400.00	72360.00	28300.	2.503	93.	37.22	0.419	4 MAIN
32	0.30	1.500	165.40	21.50	54080.00	75500.00	82130.00	32120.	2.318	96.	42.35	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7400.	HP
SHAFT POWER....	10460.	HP
TURBINE POWER..	11240.	HP
TURBINE FUEL...	8344.	LBS/HR (0.151 TONS/MILE)
PROPULSION FUEL	5357.	LBS/HR (0.152 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	14. KW
GENERATOR LUBE SYSTEM	0. KW
HELIUM COMPRESSORS...	0. KW
TOTAL LOAD..	16. KW (12.5 LBS/HR)

GEARED DRIVE SYSTEM

REF.NO. 101

MISSION PROFILE SUMMARY - BASELINE + CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	0.286	31.10	74.00	1.40	135.00	140.70	770.	3.111	11.	3.54	0.321	2	CRUISE
2	1.20	0.371	34.57	74.00	11.20	119.50	124.50	720.	6.222	24.	3.86	0.161	2	CRUISE
3	1.20	0.542	35.29	74.00	47.80	115.20	120.00	700.	9.333	36.	3.86	0.107	2	CRUISE
4	1.20	0.806	29.89	74.00	88.80	138.10	144.00	720.	12.440	48.	3.86	0.080	2	CRUISE
5	1.20	1.250	28.55	74.00	175.00	241.60	251.70	807.	13.860	60.	4.33	0.072	2	CRUISE
6	1.20	1.250	34.29	74.00	302.40	417.50	434.90	965.	14.090	72.	5.05	0.070	2	CRUISE
7	1.20	1.250	40.01	74.00	480.20	662.90	690.60	1105.	14.190	84.	5.92	0.071	2	CRUISE
8	1.20	1.250	45.72	74.00	716.80	989.80	1031.00	1296.	13.840	96.	6.94	0.072	2	CRUISE
9	1.20	1.250	51.44	74.00	1021.00	1409.00	1468.00	1516.	13.300	108.	8.13	0.075	2	CRUISE
10	1.20	1.250	57.15	74.00	1400.00	1933.00	2013.00	1770.	12.630	120.	9.49	0.079	2	CRUISE
11	6.30	1.250	62.87	74.00	1863.00	2572.00	2680.00	2061.	11.950	693.	58.02	0.084	2	CRUISE
12	6.70	1.250	68.58	74.00	2414.00	3340.00	3479.00	2393.	11.280	804.	71.65	0.089	2	CRUISE
13	7.00	1.250	74.30	74.00	3078.00	4266.00	4444.00	2770.	10.910	910.	83.84	0.096	2	CRUISE
14	7.10	1.250	80.01	74.00	3862.00	5303.00	5524.00	3196.	9.813	994.	101.40	0.102	2	CRUISE
15	6.80	1.250	85.73	74.00	4775.00	6573.00	6795.00	3677.	9.137	1020.	111.80	0.110	2	CRUISE
16	6.10	1.250	91.44	74.00	5734.00	7917.00	8246.00	4221.	8.492	976.	115.10	0.118	2	CRUISE
17	6.60	1.250	97.16	74.00	6774.00	9446.00	9841.00	4833.	7.879	1122.	142.60	0.127	2	CRUISE
18	7.20	1.300	99.72	21.50	8165.00	11330.00	11780.00	6126.	5.820	1296.	222.90	0.172	2	MAIN
19	7.70	1.300	106.30	21.50	9605.00	13210.00	13760.00	7079.	5.593	1468.	261.90	0.179	2	MAIN
20	8.00	1.300	110.00	21.50	11200.00	15410.00	16050.00	8247.	5.367	1780.	332.10	0.187	2	MAIN
21	7.50	1.300	116.30	21.50	12970.00	17840.00	18580.00	9145.	5.144	1575.	306.60	0.195	2	MAIN
22	4.30	1.300	121.90	21.50	14910.00	20510.00	21350.00	10010.	4.925	946.	192.40	0.203	2	MAIN
23	1.50	1.300	127.40	21.50	17030.00	23430.00	24410.00	10940.	4.711	345.	73.34	0.213	2	MAIN
24	1.30	1.300	133.00	21.50	19350.00	26630.00	27730.00	11940.	4.502	312.	69.40	0.222	2	MAIN
25	0.70	1.300	138.60	21.50	21870.00	30090.00	31330.00	13020.	4.300	175.	40.76	0.233	2	MAIN
26	0.50	1.300	144.30	21.50	24610.00	33850.00	35250.00	14190.	4.105	130.	31.72	0.244	2	MAIN
27	0.40	1.300	149.60	21.50	27550.00	37910.00	39480.00	15450.	3.916	108.	27.63	0.256	2	MAIN
28	0.30	1.500	140.30	21.50	32150.00	44200.00	46050.00	21030.	2.983	94.	28.20	0.336	4	MAIN
29	0.30	1.500	146.30	21.50	37250.00	51670.00	54050.00	23410.	2.775	87.	31.39	0.361	4	MAIN
30	0.30	1.500	152.60	21.50	42950.00	60150.00	62690.00	26060.	2.579	90.	34.95	0.388	4	MAIN
31	0.30	1.500	159.00	21.50	49290.00	69660.00	72360.00	29020.	2.393	93.	38.92	0.419	4	MAIN
32	0.30	1.500	165.40	21.50	56330.00	79630.00	83130.00	32320.	2.218	96.	43.35	0.452	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7478.	HP
SHAFT POWER....	10260.	HP
TURBINE POWER..	10680.	HP
TURBINE FUEL...	5943.	LBS/HR (0.157 TONS/MILE)
PROPULSION FUEL	5590.	LBS/HR (0.157 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	0.	KW
HELIUM COMPRESSORS...	0.	KW
TOTAL LOAD..	9.	KW (6.8 LBS/HR)

GEARED DRIVE SYSTEM

REF.NO. 101

MISSION PROFILE SUMMARY - BASELINE + ALTERNATORS AND CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	PER THOUSAND HOURS: TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	0.287	25.94	74.00	1.40	70.57	75.56	360.	6.222	11.	1.77	0.161	1	CRUISE
2	1.20	0.428	28.52	74.00	11.20	67.28	73.01	360.	12.440	24.	1.93	0.080	1	CRUISE
3	1.20	0.735	26.82	74.00	37.80	70.36	76.02	360.	13.670	36.	1.93	0.054	1	CRUISE
4	1.20	1.100	25.36	74.00	89.60	127.00	137.80	417.	21.470	48.	2.23	0.047	1	CRUISE
5	1.20	1.100	31.70	74.00	179.00	240.00	259.10	514.	21.780	60.	2.76	0.046	1	CRUISE
6	1.20	1.100	38.04	74.00	302.40	428.50	464.90	635.	21.180	72.	3.40	0.047	1	CRUISE
7	1.20	1.100	44.38	74.00	480.20	680.40	736.30	781.	20.090	84.	4.19	0.050	1	CRUISE
8	1.20	1.100	50.72	74.00	716.80	1016.00	1102.00	955.	18.770	96.	5.12	0.053	1	CRUISE
9	1.20	1.100	57.06	74.00	1021.00	1446.00	1569.00	1160.	17.380	108.	6.22	0.058	1	CRUISE
10	1.20	1.100	63.39	74.00	1400.00	1984.00	2153.00	1400.	16.000	120.	7.51	0.063	1	CRUISE
11	6.30	1.100	69.73	74.00	1863.00	2640.00	2865.00	1678.	14.690	693.	47.29	0.068	1	CRUISE
12	6.70	1.100	76.07	74.00	2419.00	3428.00	3720.00	1999.	13.450	804.	59.92	0.075	1	CRUISE
13	7.00	1.100	82.41	74.00	3076.00	4358.00	4729.00	2343.	12.300	910.	74.18	0.082	1	CRUISE
14	7.10	1.300	77.56	74.00	3942.00	5585.00	5505.00	3198.	9.805	994.	101.50	0.102	2	CRUISE
15	6.80	1.300	83.10	74.00	4725.00	6500.00	6771.00	3677.	9.139	1020.	111.70	0.110	2	CRUISE
16	6.10	1.300	88.64	74.00	5734.00	7839.00	8218.00	4215.	8.503	976.	114.90	0.118	2	CRUISE
17	6.40	1.300	94.18	74.00	6878.00	9462.00	9867.00	4820.	7.901	1122.	142.20	0.127	2	CRUISE
18	7.20	1.100	114.10	21.50	8165.00	11570.00	12550.00	5687.	7.090	1296.	183.30	0.141	1	MAIN
19	7.70	1.100	120.40	21.50	9603.00	13610.00	14760.00	6350.	6.702	1463.	218.90	0.150	1	MAIN
20	8.90	1.100	126.80	21.50	11200.00	15870.00	17220.00	7075.	6.357	1780.	281.90	0.158	1	MAIN
21	7.50	1.100	133.10	21.50	12970.00	18370.00	19930.00	7866.	5.980	1575.	264.20	0.168	1	MAIN
22	4.30	1.300	121.50	21.50	14810.00	20510.00	21350.00	10010.	4.925	946.	192.40	0.203	2	MAIN
23	1.50	1.300	127.40	21.50	17040.00	23630.00	24610.00	10940.	4.711	345.	73.34	0.213	2	MAIN
24	1.30	1.300	133.00	21.50	19350.00	26830.00	27730.00	11940.	4.502	312.	69.40	0.222	2	MAIN
25	0.70	1.300	138.50	21.50	21870.00	30030.00	31350.00	13020.	4.300	175.	40.76	0.233	2	MAIN
26	0.60	1.300	144.00	21.50	24610.00	33850.00	35260.00	14190.	4.105	130.	31.72	0.244	2	MAIN
27	0.40	1.300	149.60	21.50	27500.00	37810.00	39400.00	15450.	3.916	108.	27.62	0.255	2	MAIN
28	0.30	1.400	147.60	21.50	32130.00	44340.00	48110.00	19840.	3.162	84.	26.65	0.317	3	MAIN
29	0.30	1.400	154.10	21.50	37250.00	51560.00	56050.00	22740.	2.921	87.	29.87	0.343	3	MAIN
30	0.30	1.400	160.70	21.50	42950.00	59670.00	64970.00	24920.	2.696	90.	33.49	0.372	3	MAIN
31	0.30	1.500	159.00	21.50	49240.00	69460.00	72360.00	29020.	2.393	93.	38.92	0.419	4	MAIN
32	0.30	1.500	165.40	21.50	56300.00	79830.00	83130.00	32320.	2.218	96.	43.35	0.452	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10400.	HP
TURBINE POWER..	11000.	HP
TURBINE FUEL...	5017.	LBS/HR (0.142 TONS/MILE)
PROPULSION FUEL	5028.	LBS/HR (0.142 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	14.	KW
GENERATOR LUBE SYSTEM	0.	KW
HELIUM COMPRESSORS...	0.	KW
TOTAL LOAD..	14.	KW (11.0 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF.NO. 01

MISSION PROFILE SUMMARY - MAIN ONLY - BASELINE

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.036	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.34	24.96	1100.	4.373	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.59	37.80	51.96	61.70	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.81	89.60	123.20	132.90	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	29.50	175.00	240.50	248.70	1102.	10.170	60.	6.34	0.106	1 MAIN
6	1.20	1.450	30.53	31.26	302.40	415.70	429.40	1238.	10.360	72.	7.06	0.098	1 MAIN
7	1.20	1.450	35.61	32.80	480.20	660.10	681.80	1395.	11.240	84.	7.91	0.094	1 MAIN
8	1.20	1.450	40.70	33.57	716.80	985.30	1018.00	1576.	11.370	96.	8.88	0.092	1 MAIN
9	1.20	1.450	45.79	34.21	1021.00	1403.00	1450.00	1783.	11.310	108.	9.99	0.092	1 MAIN
10	1.20	1.450	50.88	34.62	1400.00	1924.00	1991.00	2018.	11.100	120.	11.25	0.094	1 MAIN
11	6.30	1.450	55.97	34.79	1863.00	2561.00	2652.00	2284.	10.790	693.	66.54	0.096	1 MAIN
12	6.70	1.450	61.05	34.77	2419.00	3325.00	3446.00	2584.	10.400	804.	79.76	0.099	1 MAIN
13	7.00	1.450	66.14	34.66	3076.00	4226.00	4355.00	2921.	9.709	910.	93.89	0.103	1 MAIN
14	7.10	1.450	71.23	34.47	3842.00	5280.00	5482.00	3299.	9.536	994.	107.20	0.108	1 MAIN
15	6.80	1.450	76.32	33.84	4729.00	6495.00	6750.00	3721.	9.029	1020.	115.50	0.113	1 MAIN
16	6.10	1.450	81.40	33.33	5734.00	7882.00	8201.00	4191.	8.991	976.	116.50	0.119	1 MAIN
17	6.60	1.450	86.49	32.75	6878.00	9454.00	9848.00	4715.	8.079	1122.	141.40	0.126	1 MAIN
18	7.20	1.450	91.58	32.11	8165.00	11220.00	11700.00	5291.	7.621	1296.	172.90	0.133	1 MAIN
19	7.70	1.450	96.67	31.44	9603.00	13200.00	13760.00	5926.	7.179	1463.	206.90	0.141	1 MAIN
20	8.50	1.450	101.60	30.75	11200.00	15390.00	16100.00	6629.	6.754	1780.	267.00	0.150	1 MAIN
21	7.50	1.450	106.80	30.04	12970.00	17820.00	18660.00	7398.	6.359	1575.	250.80	0.159	1 MAIN
22	4.30	1.450	111.90	29.32	14910.00	20490.00	21480.00	8238.	5.982	946.	160.00	0.169	1 MAIN
23	1.60	1.450	117.00	28.30	17080.00	23410.00	24470.00	10620.	4.753	345.	73.05	0.212	2 MAIN
24	1.50	1.450	122.10	24.86	19350.00	26600.00	27870.00	11630.	4.545	312.	69.20	0.222	2 MAIN
25	0.70	1.450	127.20	24.44	21870.00	30070.00	31070.00	12920.	4.334	175.	40.68	0.232	2 MAIN
26	0.50	1.450	132.30	24.00	24610.00	33820.00	34970.00	14090.	4.132	130.	31.68	0.244	2 MAIN
27	0.40	1.450	137.40	23.55	27560.00	37860.00	39190.00	15350.	3.939	108.	27.60	0.256	2 MAIN
28	0.30	1.450	142.70	21.60	32130.00	44400.00	45850.00	19210.	3.265	84.	25.88	0.308	3 MAIN
29	0.30	1.450	150.10	21.25	37250.00	51750.00	53700.00	21530.	3.017	87.	28.99	0.333	3 MAIN
30	0.30	1.450	156.50	20.87	42950.00	60010.00	62410.00	24110.	2.787	90.	32.46	0.361	3 MAIN
31	0.30	1.450	163.00	19.57	49290.00	69240.00	71960.00	28790.	2.412	93.	38.73	0.416	4 MAIN
32	0.30	1.450	169.60	19.24	56300.00	79520.00	82760.00	32020.	2.239	96.	43.06	0.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7423.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10650.	HP
TURBINE FUEL...	4988.	LBS/HR (0.141 TONS/MILE)
PROPULSION FUEL	5076.	LBS/HR (0.144 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	100.	KW
TOTAL LOAD..	110.	KW (57.7 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF.NO. 02

MISSION PROFILE SUMMARY - MAIN ONLY - RECONFIGURED ENGINE ROOM

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.10	1.40	1.42	11.27	1130.	2.036	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.39	24.95	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.59	37.80	51.96	61.66	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.83	89.60	123.20	132.80	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	29.48	175.00	240.50	248.40	1152.	10.170	60.	6.33	0.106	1 MAIN
6	1.20	1.450	30.53	31.24	302.40	415.70	426.80	1237.	10.860	72.	7.06	0.098	1 MAIN
7	1.20	1.450	35.61	32.58	480.20	660.10	680.80	1394.	11.250	84.	7.90	0.094	1 MAIN
8	1.20	1.450	40.70	33.54	716.80	985.40	1016.00	1575.	11.360	96.	8.87	0.092	1 MAIN
9	1.20	1.450	45.79	34.20	1021.00	1405.00	1447.00	1761.	11.320	108.	9.98	0.092	1 MAIN
10	1.20	1.450	50.88	34.59	1400.00	1924.00	1986.00	2016.	11.110	120.	11.24	0.094	1 MAIN
11	6.30	1.450	55.97	34.76	1861.00	2561.00	2645.00	2261.	10.800	693.	66.46	0.096	1 MAIN
12	6.70	1.450	61.05	34.74	2419.00	3326.00	3436.00	2580.	10.420	804.	79.64	0.099	1 MAIN
13	7.00	1.450	66.14	34.55	3078.00	4228.00	4371.00	2915.	9.985	910.	93.73	0.103	1 MAIN
14	7.10	1.450	71.23	34.23	3842.00	5280.00	5464.00	3293.	9.524	994.	107.00	0.108	1 MAIN
15	6.80	1.450	76.32	33.81	4725.00	6495.00	6726.00	3713.	9.048	1020.	115.30	0.113	1 MAIN
16	6.10	1.450	81.40	33.30	5734.00	7882.00	8170.00	4181.	8.571	976.	116.20	0.119	1 MAIN
17	6.60	1.450	86.49	32.72	6876.00	9454.00	9808.00	4701.	8.101	1122.	141.10	0.126	1 MAIN
18	7.20	1.450	91.58	32.06	8165.00	11223.00	11650.00	5279.	7.663	1296.	172.40	0.133	1 MAIN
19	7.70	1.450	96.67	31.42	9603.00	13200.00	13720.00	5909.	7.202	1463.	206.20	0.141	1 MAIN
20	8.90	1.450	101.80	30.72	11200.00	15390.00	16020.00	6606.	6.782	1760.	266.10	0.149	1 MAIN
21	7.50	1.450	106.80	30.01	12970.00	17820.00	18560.00	7370.	6.383	1575.	249.90	0.159	1 MAIN
22	4.30	1.450	111.90	29.30	14910.00	20490.00	21370.00	8205.	6.006	946.	159.30	0.168	1 MAIN
23	1.50	1.450	117.00	28.36	17030.00	23410.00	24430.00	10900.	4.728	345.	73.62	0.213	2 MAIN
24	1.30	1.450	122.10	24.93	19350.00	26600.00	27750.00	11920.	4.509	312.	69.76	0.224	2 MAIN
25	0.70	1.450	127.20	24.50	21870.00	30070.00	31430.00	13030.	4.296	175.	41.04	0.235	2 MAIN
26	0.50	1.450	132.30	24.05	24610.00	33820.00	35340.00	14220.	4.095	130.	31.98	0.246	2 MAIN
27	0.40	1.450	137.40	23.60	27580.00	37880.00	39600.00	15500.	3.901	108.	27.88	0.258	2 MAIN
28	0.30	1.450	143.70	21.63	32130.00	44400.00	46430.00	19830.	3.245	84.	26.04	0.310	3 MAIN
29	0.30	1.450	150.10	21.24	37250.00	51750.00	54220.00	21670.	2.937	87.	29.19	0.335	3 MAIN
30	0.30	1.450	156.50	20.90	42960.00	60010.00	63000.00	24290.	2.767	90.	32.70	0.363	3 MAIN
31	0.30	1.450	163.00	19.62	49240.00	69240.00	73030.00	29110.	2.325	93.	39.18	0.421	4 MAIN
32	0.30	1.450	169.60	19.29	56300.00	79520.00	84000.00	32400.	2.212	96.	43.60	0.454	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10640.	HP
TURBINE FUEL...	4985.	LBS/HR (0.141 TONS/MILE)
PROPULSION FUEL	5072.	LBS/HR (0.144 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	8. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	100. KW
TOTAL LOAD..	109. KW (87.5 LBS/HR)

ELECTRIC DRIVE SYSTEM REF.NO. 01

MISSION PROFILE SUMMARY - MAIN+CRSE - BASELINE

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	1.450	5.09	686.10	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1	CRUISE
2	1.20	1.450	10.18	326.20	11.20	15.34	16.68	360.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.450	15.26	177.70	37.80	51.96	55.63	360.	13.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.450	20.35	106.80	89.60	123.20	128.30	405.	22.110	48.	2.73	0.057	1	CRUISE
5	1.20	1.450	25.44	114.80	175.00	240.50	250.30	492.	22.760	60.	3.20	0.053	1	CRUISE
6	1.20	1.450	30.53	118.20	302.40	415.70	432.50	599.	22.440	72.	3.77	0.052	1	CRUISE
7	1.20	1.450	35.61	119.60	480.20	660.10	687.20	729.	21.500	84.	4.47	0.053	1	CRUISE
8	1.20	1.450	40.70	119.20	716.60	985.30	1027.00	867.	20.210	96.	5.31	0.055	1	CRUISE
9	1.20	1.450	45.79	117.70	1021.00	1403.00	1464.00	1025.	18.750	108.	6.32	0.059	1	CRUISE
10	1.20	1.450	50.88	115.50	1400.00	1924.00	2012.00	1299.	17.250	120.	7.53	0.063	1	CRUISE
11	6.30	1.450	55.97	112.70	1863.00	2561.00	2683.00	1583.	15.770	693.	46.95	0.068	1	CRUISE
12	6.70	1.450	61.05	108.70	2419.00	3325.00	3490.00	1872.	14.360	804.	59.20	0.074	1	CRUISE
13	7.00	1.450	66.14	105.00	3076.00	4228.00	4447.00	2231.	13.050	910.	73.10	0.080	1	CRUISE
14	7.10	1.450	71.23	98.56	3842.00	5280.00	5471.00	3166.	9.934	994.	103.80	0.104	2	CRUISE
15	6.80	1.450	76.32	86.39	4725.00	6495.00	6736.00	3691.	9.203	1020.	114.00	0.112	2	CRUISE
16	6.10	1.450	81.40	75.33	5734.00	7882.00	8201.00	4191.	8.951	976.	117.10	0.120	1	MAIN
17	6.60	1.450	86.49	82.75	6874.00	9454.00	9846.00	4713.	3.079	1122.	142.20	0.127	1	MAIN
18	7.20	1.450	91.58	82.11	8165.00	11230.00	11700.00	5291.	7.521	1296.	173.70	0.134	1	MAIN
19	7.70	1.450	96.67	81.44	9603.00	13200.00	13740.00	5928.	7.179	1463.	207.70	0.142	1	MAIN
20	8.90	1.450	101.80	80.75	11200.00	15390.00	16100.00	6629.	6.758	1780.	263.00	0.151	1	MAIN
21	7.50	1.450	106.80	80.04	12970.00	17820.00	18660.00	7398.	6.369	1575.	251.60	0.160	1	MAIN
22	4.30	1.450	111.90	79.32	14910.00	20490.00	21480.00	8238.	5.962	946.	160.50	0.170	1	MAIN
23	1.60	1.450	117.00	78.30	17050.00	23410.00	24570.00	10820.	4.783	345.	73.21	0.212	2	MAIN
24	1.30	1.450	122.10	24.88	19350.00	26600.00	27870.00	11830.	4.595	312.	69.34	0.222	2	MAIN
25	0.70	1.450	127.20	24.44	21870.00	30070.00	31570.00	12920.	4.334	175.	40.75	0.233	2	MAIN
26	0.50	1.450	132.30	24.00	24610.00	33820.00	34970.00	14090.	4.132	130.	31.74	0.244	2	MAIN
27	0.40	1.450	137.40	23.55	27560.00	37880.00	39180.00	15350.	3.959	108.	27.65	0.256	2	MAIN
28	0.30	1.450	142.70	21.60	32150.00	44400.00	46050.00	19210.	3.265	84.	25.91	0.308	3	MAIN
29	0.30	1.450	150.10	21.25	37250.00	51750.00	53750.00	21530.	3.017	87.	29.03	0.334	3	MAIN
30	0.30	1.450	156.50	20.87	42950.00	60010.00	62410.00	24110.	2.757	90.	32.49	0.361	3	MAIN
31	0.30	1.450	162.80	19.57	49240.00	69140.00	71960.00	28790.	2.412	93.	38.76	0.417	4	MAIN
32	0.30	1.450	168.60	19.24	56300.00	79520.00	82760.00	32320.	2.259	96.	43.09	0.449	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10660.	HP
TURBINE FUEL...	4750.	LBS/HR (0.135 TONS/MILE)
PROPULSION FUEL	4862.	LBS/HR (0.138 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	130.	KW
TOTAL LOAD..	140.	KW (111.9 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF.NO. 02

MISSION PROFILE SUMMARY - MAIN + CRUISE - RECONFIGURED ENGINE ROOM

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	PER THOUSAND HOURS: TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	1.450	5.39	686.10	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1	CRUISE
2	1.20	1.450	10.18	326.10	11.20	15.34	18.89	360.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.450	15.26	177.60	47.60	51.96	59.70	360.	13.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.450	20.35	108.90	89.60	123.20	128.60	405.	22.100	43.	2.73	0.057	1	CRUISE
5	1.20	1.450	25.44	114.90	175.00	240.50	250.90	492.	22.740	60.	3.20	0.053	1	CRUISE
6	1.20	1.450	30.53	116.40	302.40	415.70	433.80	600.	22.410	72.	3.73	0.052	1	CRUISE
7	1.20	1.450	35.61	118.70	480.20	660.10	689.50	730.	21.470	84.	4.48	0.053	1	CRUISE
8	1.20	1.450	40.70	119.40	716.80	985.30	1031.00	888.	20.170	96.	5.32	0.055	1	CRUISE
9	1.20	1.450	45.79	117.90	1021.00	1405.00	1470.00	1078.	18.710	108.	6.24	0.059	1	CRUISE
10	1.20	1.450	50.88	119.40	1400.00	1924.00	2021.00	1303.	17.200	120.	7.55	0.063	1	CRUISE
11	6.30	1.450	55.97	117.30	1863.00	2561.00	2697.00	1568.	15.710	693.	47.11	0.068	1	CRUISE
12	6.70	1.450	61.05	108.90	2419.00	3325.00	3510.00	1879.	14.300	804.	59.43	0.074	1	CRUISE
13	7.00	1.450	66.14	105.10	3078.00	4228.00	4474.00	2241.	12.990	910.	73.43	0.081	1	CRUISE
14	7.10	1.450	71.23	88.77	3842.00	5260.00	5524.00	3187.	9.840	994.	104.50	0.105	2	CRUISE
15	6.80	1.450	76.32	88.57	4725.00	6495.00	6806.00	3677.	9.137	1020.	115.00	0.113	2	CRUISE
16	6.10	1.450	81.40	33.30	5734.00	7882.00	8170.00	4161.	8.571	976.	116.00	0.120	1	MAIN
17	6.50	1.450	86.49	32.72	6878.00	9454.00	9808.00	4701.	8.101	1122.	141.80	0.126	1	MAIN
18	7.20	1.450	91.58	32.06	8185.00	11250.00	11650.00	5275.	7.643	1296.	173.20	0.134	1	MAIN
19	7.70	1.450	96.67	31.42	9603.00	13200.00	13720.00	5909.	7.202	1463.	207.00	0.142	1	MAIN
20	8.40	1.450	101.80	30.72	11200.00	15390.00	15920.00	6606.	6.787	1780.	257.00	0.150	1	MAIN
21	7.50	1.450	106.80	30.01	12970.00	17820.00	18560.00	7370.	6.383	1575.	250.70	0.159	1	MAIN
22	4.30	1.450	111.90	29.30	14910.00	20490.00	21370.00	8205.	6.006	946.	159.80	0.169	1	MAIN
23	1.50	1.450	117.00	28.36	17050.00	23410.00	24430.00	10900.	4.728	345.	73.78	0.214	2	MAIN
24	1.30	1.450	122.10	24.60	19390.00	26650.00	27760.00	11920.	4.505	312.	69.92	0.224	2	MAIN
25	0.70	1.450	127.20	24.60	21870.00	30070.00	31430.00	13030.	4.298	175.	41.12	0.235	2	MAIN
26	0.50	1.450	132.30	24.05	24610.00	33820.00	35390.00	14220.	4.095	130.	32.04	0.246	2	MAIN
27	0.40	1.450	137.40	25.60	27560.00	37880.00	39660.00	15500.	3.901	108.	27.92	0.259	2	MAIN
28	0.30	1.450	142.70	21.67	32130.00	44400.00	46470.00	19330.	3.245	84.	26.07	0.310	3	MAIN
29	0.30	1.450	150.10	21.28	37750.00	51750.00	54220.00	21670.	2.997	87.	29.22	0.336	3	MAIN
30	0.30	1.450	156.50	20.90	42950.00	60010.00	63000.00	24290.	2.767	90.	32.74	0.364	3	MAIN
31	0.30	1.450	163.00	19.62	49290.00	69240.00	73030.00	29110.	2.535	93.	39.21	0.422	4	MAIN
32	0.30	1.450	169.80	19.29	56330.00	79520.00	84050.00	32400.	2.212	96.	43.64	0.455	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10670.	HP
TURBINE FUEL...	4753.	LBS/HR (0.135 TONS/MILE)
PROPULSION FUEL	4865.	LBS/HR (0.134 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	130.	KW
TOTAL LOAD..	140.	KW (112.1 LBS/HR)

4C-2

ELECTRIC DRIVE SYSTEM REF.NO. 03

MISSION PROFILE SUMMARY - MAIN + CRUISE - OPTIMUM CONFIGURATION

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	1.450	5.09	686.10	1.40	1.97	5.18	360.	6.222	11.	2.28	0.208	1	CRUISE
2	1.20	1.450	10.18	326.20	11.20	15.39	16.64	360.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.450	15.26	178.00	37.80	51.96	55.64	360.	18.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.450	20.35	108.60	89.60	123.20	127.70	405.	22.130	48.	2.73	0.057	1	CRUISE
5	1.20	1.450	25.44	114.60	175.00	240.50	244.90	491.	22.800	60.	3.19	0.053	1	CRUISE
6	1.20	1.450	30.53	117.90	302.40	415.70	424.90	547.	22.500	72.	3.76	0.052	1	CRUISE
7	1.20	1.450	35.61	119.20	480.20	660.10	681.60	727.	21.580	84.	4.46	0.053	1	CRUISE
8	1.20	1.450	40.70	118.90	716.80	985.50	1017.00	882.	20.310	96.	5.29	0.055	1	CRUISE
9	1.20	1.450	45.79	117.40	1021.00	1403.00	1449.00	1069.	18.870	108.	6.29	0.058	1	CRUISE
10	1.20	1.450	50.88	114.90	1400.00	1924.00	1989.00	1289.	17.370	120.	7.47	0.062	1	CRUISE
11	6.30	1.450	55.97	111.90	1868.00	2561.00	2644.00	1550.	15.900	693.	43.57	0.067	1	CRUISE
12	6.70	1.450	61.05	108.40	2419.00	3325.00	3442.00	1854.	14.500	804.	58.63	0.073	1	CRUISE
13	7.00	1.450	66.14	104.70	3076.00	4228.00	4381.00	2265.	13.230	910.	72.30	0.079	1	CRUISE
14	7.10	1.450	71.23	100.90	3842.00	5280.00	5479.00	2813.	12.000	994.	86.24	0.087	1	CRUISE
15	6.80	1.450	76.32	86.36	4725.00	6493.00	6774.00	3646.	9.215	1020.	114.00	0.112	2	CRUISE
16	6.10	1.450	81.40	33.30	5734.00	7882.00	8170.00	4181.	8.571	976.	116.80	0.120	1	MAIN
17	6.60	1.450	86.49	32.72	6878.00	9454.00	9808.00	4701.	3.101	1122.	141.80	0.126	1	MAIN
18	7.20	1.450	91.58	32.08	8199.00	11220.00	11650.00	5275.	7.643	1296.	173.20	0.134	1	MAIN
19	7.70	1.450	96.67	31.42	9604.00	13200.00	13720.00	5909.	7.202	1468.	207.00	0.142	1	MAIN
20	8.90	1.450	101.80	30.72	11200.00	15390.00	16020.00	6606.	6.782	1780.	267.00	0.150	1	MAIN
21	7.50	1.450	106.80	30.01	12970.00	17820.00	18550.00	7370.	6.383	1575.	250.70	0.159	1	MAIN
22	4.30	1.450	111.90	29.30	14910.00	20490.00	21370.00	8205.	6.006	946.	159.80	0.169	1	MAIN
23	1.50	1.450	117.00	25.36	17050.00	23410.00	24430.00	10960.	4.728	345.	73.73	0.214	2	MAIN
24	1.30	1.450	122.10	24.93	19350.00	26600.00	27780.00	11920.	4.509	312.	69.92	0.224	2	MAIN
25	0.70	1.450	127.20	24.50	21870.00	30070.00	31430.00	13030.	4.298	175.	41.12	0.235	2	MAIN
26	0.50	1.450	132.30	24.05	24610.00	33820.00	35390.00	14220.	4.095	130.	32.04	0.246	2	MAIN
27	0.40	1.450	137.40	23.60	27550.00	37860.00	39560.00	15500.	3.901	108.	27.42	0.259	2	MAIN
28	0.30	1.450	142.70	21.63	32150.00	44400.00	46430.00	19330.	3.245	84.	26.07	0.310	3	MAIN
29	0.30	1.450	150.10	21.28	37250.00	51750.00	54220.00	21670.	2.997	87.	29.22	0.336	3	MAIN
30	0.30	1.450	156.50	20.90	42950.00	60010.00	63000.00	24290.	2.767	90.	32.74	0.364	3	MAIN
31	0.30	1.450	163.00	19.62	49240.00	69240.00	73030.00	29110.	2.385	93.	39.21	0.422	4	MAIN
32	0.30	1.450	169.60	19.29	56300.00	79520.00	84360.00	32400.	2.212	96.	43.04	0.455	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10690.	HP
TURBINE FUEL...	4705.	LBS/HR (0.133 TONS/MILE)
PROPULSION FUEL	4816.	LBS/HR (0.136 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	8. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	130. KW
TOTAL LOAD..	140. KW (111.6 LBS/HR)

GEARED DRIVE SYSTEM

REF.NO. 101

MISSION PROFILE SUMMARY - BASELINE - VARIABLE PITCH

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	PER THOUSAND HOURS: TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	0.278	44.08	21.50	1.40	440.20	458.60	2200.	1.018	11.	10.81	0.982	2 MAIN
2	1.20	0.305	47.58	21.50	11.20	410.20	427.30	2200.	2.036	24.	11.79	0.491	2 MAIN
3	1.20	0.378	50.78	21.50	37.80	374.50	390.10	2200.	3.095	36.	11.79	0.327	2 MAIN
4	1.20	0.487	52.03	21.50	89.60	353.40	373.30	2200.	4.073	48.	11.79	0.246	2 MAIN
5	1.20	0.646	50.07	21.50	175.00	383.10	399.00	2200.	5.091	60.	11.79	0.196	2 MAIN
6	1.20	0.867	42.35	21.50	302.40	451.50	470.30	2200.	6.109	72.	11.79	0.164	2 MAIN
7	1.20	1.301	38.78	21.50	480.20	660.60	688.20	2355.	8.659	84.	12.62	0.150	2 MAIN
8	1.20	1.270	45.26	21.50	716.80	983.20	1029.00	2500.	6.819	96.	13.88	0.145	2 MAIN
9	1.20	1.247	51.57	21.50	1021.00	1409.00	1466.00	2853.	7.062	108.	15.30	0.142	2 MAIN
10	1.20	1.232	57.37	21.50	1400.00	1936.00	2017.00	3151.	7.109	120.	16.89	0.141	2 MAIN
11	6.80	1.220	64.15	21.50	1863.00	2581.00	2688.00	3480.	7.080	608.	97.93	0.141	2 MAIN
12	6.70	1.212	70.13	21.50	2419.00	3352.00	3492.00	3845.	6.991	804.	115.10	0.143	2 MAIN
13	7.00	1.207	76.49	21.50	3076.00	4267.00	4445.00	4247.	6.856	910.	132.80	0.146	2 MAIN
14	7.10	1.208	82.28	21.50	3847.00	5329.00	5551.00	4690.	6.687	994.	148.80	0.150	2 MAIN
15	6.80	1.209	88.16	21.50	4725.00	6554.00	6827.00	5174.	6.494	1020.	157.20	0.154	2 MAIN
16	6.10	1.211	93.28	21.50	5734.00	7952.00	8283.00	5704.	6.283	976.	155.50	0.159	2 MAIN
17	6.60	1.216	99.30	21.50	6878.00	9530.00	9927.00	6281.	6.062	1172.	185.30	0.158	2 MAIN
18	7.20	1.222	104.60	21.50	8165.00	11310.00	11780.00	6910.	5.835	1296.	222.40	0.172	2 MAIN
19	7.70	1.231	110.10	21.50	9603.00	13280.00	13840.00	7598.	5.605	1443.	261.20	0.179	2 MAIN
20	8.00	1.238	115.20	21.50	11200.00	15480.00	16120.00	8332.	5.377	1780.	331.50	0.186	2 MAIN
21	7.50	1.247	120.30	21.50	12970.00	17910.00	18650.00	9133.	5.150	1575.	306.20	0.194	2 MAIN
22	4.30	1.259	125.10	21.50	14910.00	20570.00	21420.00	9999.	4.929	946.	192.20	0.203	2 MAIN
23	1.50	1.273	129.50	21.50	17030.00	23470.00	24450.00	10930.	4.718	345.	73.32	0.213	2 MAIN
24	1.30	1.288	134.40	21.50	19350.00	26650.00	27760.00	11940.	4.508	313.	69.39	0.222	2 MAIN
25	0.70	1.299	139.70	21.50	21870.00	30100.00	31350.00	13020.	4.300	173.	40.76	0.233	2 MAIN
26	0.50	1.313	143.00	21.50	24610.00	33880.00	35240.00	14100.	4.105	130.	31.72	0.244	2 MAIN
27	0.40	1.328	147.10	21.50	27560.00	37870.00	39450.00	15440.	3.917	108.	27.61	0.256	2 MAIN
28	0.30	1.472	140.[illegible]	21.50	32130.00	44440.00	46290.00	21020.	2.983	84.	28.20	0.336	4 MAIN
29	0.30	1.479	147.[illegible]	21.50	37250.00	51820.00	53980.00	23400.	2.776	87.	31.39	0.361	4 MAIN
30	0.30	1.489	153.50	21.50	42950.00	60140.00	62640.00	26060.	2.579	90.	34.95	0.388	4 MAIN
31	0.30	1.508	158.40	21.50	49290.00	69600.00	72390.00	29020.	2.383	93.	38.92	0.419	4 MAIN
32	0.30	1.527	163.20	21.50	56300.00	79970.00	83310.00	32310.	2.218	96.	43.34	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10300.	HP
TURBINE POWER..	10730.	HP
TURBINE FUEL...	4686.	LBS/HR (0.191 TONS/MILE)
PROPULSION FUEL	4393.	LBS/HR (0.181 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	0.	KW
HELIUM COMPRESSORS...	0.	KW
TOTAL LOAD..	9.	KW (6.9 LBS/HR)

92-D

GEARED DRIVE SYSTEM

REF.NO. 101

MISSION PROFILE SUMMARY - BASELINE + ALTERNATORS + CRUISE TURBINES - VARIABLE PITCH

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	0.287	25.94	74.00	1.40	70.57	76.58	380.	6.222	11.	1.77	0.161	1 CRUISE
2	1.20	0.428	29.52	74.00	11.20	67.26	73.01	360.	12.440	24.	1.93	0.080	1 CRUISE
3	1.20	0.735	26.82	74.00	37.80	70.06	76.02	360.	18.670	36.	1.93	0.054	1 CRUISE
4	1.20	1.115	25.15	74.00	89.60	126.60	137.40	417.	21.490	48.	2.23	0.047	1 CRUISE
5	1.20	1.094	31.91	74.00	175.00	248.60	269.70	514.	21.780	60.	2.76	0.046	1 CRUISE
6	1.20	1.079	38.69	74.00	302.40	431.60	468.00	634.	21.180	72.	3.40	0.047	1 CRUISE
7	1.20	1.074	45.37	74.00	480.20	688.30	744.70	780.	20.090	84.	4.18	0.050	1 CRUISE
8	1.20	1.079	51.58	74.00	716.80	1022.00	1109.00	954.	18.770	96.	5.12	0.053	1 CRUISE
9	1.20	1.089	57.58	74.00	1021.00	1451.00	1575.00	1150.	17.380	108.	6.22	0.058	1 CRUISE
10	1.20	1.100	63.42	74.00	1400.00	1984.00	2153.00	1400.	16.000	120.	7.51	0.063	1 CRUISE
11	6.30	1.113	69.15	74.00	1863.00	2633.00	2856.00	1678.	14.690	693.	47.28	0.068	1 CRUISE
12	6.70	1.131	74.42	74.00	2419.00	3402.00	3692.00	1997.	13.460	804.	59.88	0.074	1 CRUISE
13	7.00	1.151	78.47	74.00	3078.00	4307.00	4674.00	2364.	12.320	910.	74.04	0.081	1 CRUISE
14	7.10	1.259	79.50	74.00	3842.00	5298.00	5817.00	3198.	9.813	994.	101.40	0.102	2 CRUISE
15	6.80	1.279	84.25	74.00	4726.00	6609.00	6760.00	3676.	9.141	1020.	111.70	0.110	2 CRUISE
16	6.10	1.299	88.74	74.00	5734.00	7890.00	8218.00	4215.	8.503	976.	114.90	0.118	2 CRUISE
17	6.60	1.322	93.05	74.00	6876.00	9454.00	9848.00	4819.	7.903	1122.	142.20	0.127	2 CRUISE
18	7.20	1.122	112.30	21.50	8165.00	11510.00	12480.00	5685.	7.092	1296.	183.20	0.141	1 MAIN
19	7.70	1.133	117.60	21.50	9603.00	13490.00	14540.00	6345.	6.707	1468.	218.70	0.150	1 MAIN
20	8.40	1.146	123.70	21.50	11200.00	15700.00	17040.00	7064.	6.342	1780.	281.50	0.158	1 MAIN
21	7.50	1.158	128.20	21.50	12970.00	18180.00	19590.00	7848.	5.995	1575.	263.50	0.167	1 MAIN
22	4.30	1.259	128.10	21.50	14910.00	20570.00	21420.00	9999.	4.929	946.	192.20	0.203	2 MAIN
23	1.50	1.273	129.50	21.50	17050.00	23470.00	24450.00	10930.	4.712	345.	73.32	0.213	2 MAIN
24	1.30	1.283	134.40	21.50	19360.00	26660.00	27760.00	11940.	4.503	312.	69.39	0.222	2 MAIN
25	0.70	1.299	138.70	21.50	21870.00	30100.00	31350.00	13020.	4.300	175.	40.76	0.233	2 MAIN
26	0.50	1.318	143.00	21.50	24610.00	33880.00	35240.00	14190.	4.105	130.	31.72	0.244	2 MAIN
27	0.40	1.328	147.10	21.50	27560.00	37870.00	39450.00	15440.	3.917	108.	27.61	0.256	2 MAIN
28	0.30	1.397	148.10	21.50	32150.00	44330.00	46100.00	19840.	3.162	84.	26.65	0.317	3 MAIN
29	0.30	1.408	153.40	21.50	37250.00	51670.00	53870.00	22230.	2.922	87.	29.87	0.343	3 MAIN
30	0.30	1.420	159.10	21.50	42950.00	59920.00	62020.00	24920.	2.607	90.	33.48	0.372	3 MAIN
31	0.30	1.508	158.40	21.50	49290.00	69500.00	72390.00	29020.	2.393	93.	38.92	0.419	4 MAIN
32	0.30	1.527	163.20	21.50	56300.00	79970.00	83310.00	32310.	2.218	96.	43.34	0.452	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10350.	HP
TURBINE POWER..	11080.	HP
TURBINE FUEL...	5018.	LBS/HR (0.142 TONS/MILE)
PROPULSION FUEL	5024.	LBS/HR (0.142 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	14.	KW
GENERATOR LUBE SYSTEM	0.	KW
HELIUM COMPRESSORS...	0.	KW
TOTAL LOAD..	14.	KW (11.0 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF.NO. 01

MISSION PROFILE SUMMARY - MAIN ONLY - VARIABLE P/D

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
					PER THOUSAND HOURS									
1	1.10	1.500	4.96	298.70	1.40	1.93	11.27	1100.	2.036	11.	5.80	0.527	1	MAIN
2	1.20	1.500	9.92	147.20	11.20	15.42	24.96	1100.	4.073	24.	6.33	0.264	1	MAIN
3	1.20	1.500	14.87	98.99	37.80	52.05	61.73	1100.	6.109	36.	6.33	0.176	1	MAIN
4	1.20	1.500	19.83	63.42	89.60	123.40	133.00	1100.	8.145	48.	6.33	0.132	1	MAIN
5	1.20	1.466	26.08	28.77	175.00	240.80	248.60	1102.	10.170	60.	6.34	0.106	1	MAIN
6	1.20	1.390	31.51	30.93	302.40	415.20	429.10	1237.	10.380	72.	7.06	0.098	1	MAIN
7	1.20	1.386	36.93	31.43	480.20	659.40	681.10	1395.	11.240	84.	7.91	0.094	1	MAIN
8	1.20	1.380	42.34	32.25	716.80	984.20	1017.00	1575.	11.380	96.	8.67	0.092	1	MAIN
9	1.20	1.36.	47.96	32.66	1021.00	1401.00	1446.00	1782.	11.320	108.	9.98	0.092	1	MAIN
10	1.20	1.364	53.42	32.96	1400.00	1923.00	1987.00	2016.	11.110	120.	11.24	0.094	1	MAIN
11	6.30	1.364	58.76	33.12	1868.00	2559.00	2646.00	2282.	10.800	693.	66.48	0.096	1	MAIN
12	6.70	1.360	64.25	33.02	2419.00	3322.00	3438.00	2581.	10.420	804.	79.67	0.099	1	MAIN
13	7.00	1.354	69.84	32.73	3076.00	4224.00	4374.00	2917.	9.982	910.	93.76	0.103	1	MAIN
14	7.10	1.346	75.57	32.26	3842.00	5277.00	5467.00	3294.	9.520	994.	107.10	0.108	1	MAIN
15	6.80	1.346	80.97	31.87	4726.00	6490.00	6730.00	3715.	9.045	1020.	115.30	0.113	1	MAIN
16	6.10	1.346	86.36	31.39	5734.00	7877.00	8175.00	4183.	8.568	976.	116.20	0.119	1	MAIN
17	6.60	1.336	92.30	30.66	6878.00	9450.00	9814.00	4703.	8.098	1122.	141.10	0.126	1	MAIN
18	7.20	1.332	97.73	30.07	8165.00	11220.00	11660.00	5278.	7.640	1296.	172.50	0.133	1	MAIN
19	7.70	1.327	103.70	29.30	9603.00	13200.00	13730.00	5911.	7.200	1463.	206.30	0.141	1	MAIN
20	8.90	1.327	109.10	28.65	11200.00	15390.00	16030.00	6609.	6.779	1780.	266.20	0.150	1	MAIN
21	7.50	1.327	114.60	27.99	12970.00	17820.00	18570.00	7373.	6.360	1575.	250.00	0.159	1	MAIN
22	4.30	1.325	120.20	27.29	14910.00	20490.00	21380.00	8208.	6.004	946.	159.40	0.168	1	MAIN
23	1.50	1.346	123.90	26.89	17060.00	23400.00	24400.00	10800.	4.772	345.	72.91	0.211	2	MAIN
24	1.30	1.346	129.50	26.44	19350.00	26580.00	27700.00	11600.	4.554	312.	69.06	0.221	2	MAIN
25	0.70	1.346	134.90	26.03	21870.00	30050.00	30980.00	12690.	4.344	175.	40.59	0.232	2	MAIN
26	0.50	1.346	140.30	25.61	24610.00	33800.00	34860.00	14060.	4.142	130.	31.61	0.243	2	MAIN
27	0.40	1.346	145.70	25.19	27560.00	37850.00	39060.00	15320.	3.948	108.	27.53	0.255	2	MAIN
28	0.30	1.321	154.60	25.06	32160.00	44340.00	45840.00	19150.	3.276	84.	25.79	0.307	3	MAIN
29	0.30	1.301	163.50	19.61	37250.00	51530.00	53410.00	21450.	3.032	87.	28.84	0.332	3	MAIN
30	0.30	1.275	173.00	18.06	42990.00	59520.00	61690.00	23960.	2.805	90.	32.24	0.358	3	MAIN
31	0.30	1.305	176.80	18.41	49290.00	68860.00	71310.00	28610.	2.427	93.	38.48	0.414	4	MAIN
32	0.30	1.311	183.20	18.44	56300.00	79020.00	81920.00	31600.	2.254	96.	42.76	0.445	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10220.	HP
TURBINE POWER..	10610.	HP
TURBINE FUEL ...	4975.	LBS/HR (0.141 TONS/MILE)
PROPULSION FUEL	5068.	LBS/HR (0.143 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	8.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	100.	KW
TOTAL LOAD..	109.	KW (87.1 LBS/HR)

ELECTRIC DRIVE SYSTEM REF.NO. 01

MISSION PROFILE SUMMARY - MAIN + CRUISE - VARIABLE P/D

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (N4/TON)	NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
						PER THOUSAND HOURS								
1	1.10	1.500	4.96	704.10	1.40	1.93	5.16	360.	6.222	11.	2.23	0.208	1	CRUISE
2	1.20	1.500	9.92	334.70	11.20	15.42	13.48	360.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.500	14.87	102.30	37.60	52.05	55.68	360.	13.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.400	20.94	105.70	88.80	123.00	128.30	405.	22.110	43.	2.73	0.057	1	CRUISE
5	1.20	1.366	26.35	110.80	175.00	240.30	250.10	492.	22.770	60.	3.20	0.053	1	CRUISE
6	1.20	1.372	31.40	113.10	302.40	415.20	431.90	599.	22.430	72.	3.77	0.052	1	CRUISE
7	1.20	1.364	37.39	113.80	486.20	659.40	685.90	729.	21.520	84.	4.47	0.053	1	CRUISE
8	1.20	1.354	42.98	112.90	716.80	984.50	1024.00	885.	20.240	96.	5.31	0.055	1	CRUISE
9	1.20	1.346	48.53	110.90	1041.00	1432.00	1490.00	1075.	18.730	108.	6.31	0.058	1	CRUISE
10	1.20	1.346	53.08	108.60	1400.00	1926.00	2005.00	1295.	17.280	120.	7.51	0.063	1	CRUISE
11	6.30	1.334	53.80	104.80	1866.00	2560.00	2673.00	1559.	15.810	693.	46.84	0.068	1	CRUISE
12	6.70	1.327	65.47	101.30	2419.00	3325.00	3475.00	1866.	14.450	804.	59.03	0.073	1	CRUISE
13	7.00	1.325	71.01	97.75	3076.00	4227.00	4426.00	2223.	13.100	910.	72.85	0.080	1	CRUISE
14	7.10	1.346	75.57	82.45	3942.00	5277.00	5456.00	3161.	9.922	994.	103.60	0.104	2	CRUISE
15	6.80	1.346	80.87	81.39	4729.00	6490.00	6716.00	3842.	9.223	1020.	113.90	0.112	2	CRUISE
16	6.10	1.346	86.36	81.39	5734.00	7877.00	8175.00	4183.	8.568	976.	116.90	0.120	1	MAIN
17	6.60	1.336	92.50	80.06	6870.00	9450.00	9814.00	4703.	8.095	1122.	141.80	0.126	1	MAIN
18	7.20	1.332	97.75	80.07	8169.00	11220.00	11660.00	5278.	7.640	1296.	173.20	0.134	1	MAIN
19	7.70	1.327	103.70	79.30	9803.00	13200.00	13750.00	5911.	7.200	1483.	207.10	0.142	1	MAIN
20	8.90	1.327	109.10	78.85	11700.00	15590.00	16030.00	6609.	6.779	1780.	267.10	0.150	1	MAIN
21	7.50	1.327	114.60	77.99	12970.00	17620.00	18570.00	7373.	6.380	1575.	250.80	0.159	1	MAIN
22	4.30	1.325	120.20	77.29	14910.00	20490.00	21880.00	8208.	6.004	946.	159.90	0.169	1	MAIN
23	1.50	1.346	123.90	78.68	17050.00	23400.00	24100.00	10800.	4.772	345.	73.08	0.212	2	MAIN
24	1.30	1.346	129.50	78.44	19850.00	26800.00	27600.00	11800.	4.594	312.	69.20	0.222	2	MAIN
25	0.70	1.346	134.90	78.08	21570.00	28800.00	29980.00	12360.	4.344	175.	40.67	0.232	2	MAIN
26	0.50	1.346	140.30	77.61	24610.00	33800.00	34860.00	14060.	4.142	130.	31.66	0.244	2	MAIN
27	0.40	1.346	145.70	77.19	27560.00	37850.00	39060.00	15320.	3.948	108.	27.58	0.255	2	MAIN
28	0.30	1.321	154.60	70.06	32130.00	44340.00	45840.00	19150.	3.276	84.	25.82	0.307	3	MAIN
29	0.30	1.301	163.30	19.51	37250.00	51630.00	53410.00	21430.	3.082	87.	28.88	0.332	3	MAIN
30	0.30	1.275	173.00	16.86	42960.00	59620.00	61690.00	23960.	2.805	90.	32.28	0.359	3	MAIN
31	0.30	1.305	176.80	18.41	49240.00	68860.00	71310.00	28610.	2.427	93.	38.51	0.414	4	MAIN
32	0.30	1.311	183.20	18.44	56300.00	79020.00	81920.00	31800.	2.254	96.	42.79	0.446	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10220.	HP
TURBINE POWER..	10620.	HP
TURBINE FUEL...	4736.	LBS/HR (0.134 TONS/MILE)
PROPULSION FUEL	4848.	LBS/HR (0.137 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	8. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	130. KW
TOTAL LOAD..	139. KW (111.3 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF. NO. 01

MISSION PROFILE SUMMARY - FIELDS FIXED AT 90 PERCENT - MAIN TURBINES ONLY

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.036	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.39	24.96	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.58	37.80	51.96	61.69	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.80	89.60	123.20	132.90	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	20.10	175.00	240.50	247.60	1131.	9.902	60.	6.49	0.108	1 MAIN
6	1.20	1.450	30.53	20.14	302.40	415.70	427.40	1291.	10.410	72.	7.35	0.102	1 MAIN
7	1.20	1.450	35.61	20.18	480.20	660.10	676.40	1480.	10.600	84.	8.36	0.100	1 MAIN
8	1.20	1.450	40.70	20.21	716.80	985.30	1013.00	1698.	10.550	96.	9.53	0.099	1 MAIN
9	1.20	1.450	45.79	20.25	1021.00	1403.00	1443.00	1948.	10.350	108.	10.87	0.101	1 MAIN
10	1.20	1.450	50.88	20.29	1400.00	1924.00	1981.00	2230.	10.040	120.	12.39	0.103	1 MAIN
11	6.30	1.450	55.97	20.32	1863.00	2561.00	2639.00	2547.	9.673	693.	73.95	0.107	1 MAIN
12	6.70	1.450	61.05	20.36	2419.00	3325.00	3429.00	2900.	9.269	804.	89.21	0.111	1 MAIN
13	7.00	1.450	66.14	20.40	3078.00	4228.00	4366.00	3291.	8.850	910.	105.40	0.116	1 MAIN
14	7.10	1.450	71.23	20.43	3842.00	5280.00	5459.00	3721.	8.429	994.	120.60	0.121	1 MAIN
15	6.50	1.450	76.32	20.47	4725.00	6495.00	6724.00	4192.	8.014	1020.	129.80	0.127	1 MAIN
16	6.10	1.450	81.40	20.51	5734.00	7882.00	8172.00	4708.	7.613	976.	130.50	0.134	1 MAIN
17	6.60	1.450	86.49	20.55	6878.00	9454.00	9816.00	5270.	7.226	1122.	157.80	0.141	1 MAIN
18	7.20	1.450	91.58	20.58	8165.00	11220.00	11670.00	5880.	6.857	1296.	191.80	0.148	1 MAIN
19	7.70	1.450	96.67	20.62	9603.00	13200.00	13750.00	6542.	6.505	1463.	228.00	0.156	1 MAIN
20	8.90	1.450	101.80	20.66	11280.00	15390.00	16060.00	7259.	6.172	1780.	292.00	0.164	1 MAIN
21	7.50	1.450	106.80	20.69	12970.00	17820.00	18620.00	8033.	5.856	1575.	272.10	0.173	1 MAIN
22	4.30	1.450	111.90	20.36	14910.00	20490.00	21090.00	10190.	4.838	946.	197.30	0.209	2 MAIN
23	1.50	1.450	117.00	20.38	17030.00	23410.00	24120.00	11120.	4.635	345.	75.06	0.218	2 MAIN
24	1.30	1.450	122.10	20.40	19350.00	26600.00	27430.00	12110.	4.438	312.	70.85	0.227	2 MAIN
25	0.70	1.450	127.20	20.42	21870.00	30070.00	31030.00	13180.	4.248	175.	41.50	0.237	2 MAIN
26	0.50	1.450	132.30	20.44	24610.00	33820.00	34930.00	14330.	4.065	130.	32.21	0.248	2 MAIN
27	0.40	1.450	137.40	20.46	27560.00	37880.00	39150.00	15560.	3.888	108.	27.96	0.259	2 MAIN
28	0.30	1.450	142.70	20.49	32130.00	44400.00	46030.00	19240.	3.260	84.	25.92	0.309	3 MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	87.	29.00	0.333	3 MAIN
30	0.30	1.450	156.50	20.57	43950.00	60010.00	62400.00	24120.	2.787	90.	32.46	0.361	3 MAIN
31	0.30	1.450	163.00	20.55	49290.00	69240.00	71990.00	28860.	2.406	93.	38.82	0.417	4 MAIN
32	0.30	1.450	169.60	20.59	56300.00	79520.00	82810.00	32150.	2.230	96.	43.24	0.450	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10610.	HP
TURBINE FUEL...	5400.	LBS/HR (0.155 TONS/MILE)
PROPULSION FUEL	5567.	LBS/HR (0.158 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	8. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	100. KW
TOTAL LOAD..	109. KW (87.1 LBS/HR)

REF.NO. 01

ELECTRIC DRIVE SYSTEM

MISSION PROFILE SUMMARY - FIELDS FIXED AT 90 PERCENT - MAIN + CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	1.450	5.09	686.10	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1	CRUISE
2	1.20	1.450	10.18	326.10	11.20	15.39	18.88	360.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.450	15.26	177.70	37.80	51.96	55.63	360.	18.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.450	20.35	97.96	89.60	123.20	127.90	409.	21.880	48.	2.76	0.057	1	CRUISE
5	1.20	1.450	25.44	86.24	175.00	240.50	249.40	502.	22.300	60.	3.35	0.054	1	CRUISE
6	1.20	1.450	30.53	86.52	302.40	415.70	431.00	617.	21.790	72.	3.87	0.054	1	CRUISE
7	1.20	1.450	35.61	88.81	480.20	660.10	685.00	756.	20.750	84.	4.61	0.055	1	CRUISE
8	1.20	1.450	40.70	89.09	716.80	985.30	1024.00	921.	19.460	96.	5.50	0.057	1	CRUISE
9	1.20	1.450	45.79	89.37	1021.00	1403.00	1461.00	1116.	18.070	108.	6.54	0.061	1	CRUISE
10	1.20	1.450	50.88	89.65	1400.00	1924.00	2008.00	1343.	16.680	120.	7.76	0.065	1	CRUISE
11	6.30	1.450	55.97	89.94	1863.00	2561.00	2679.00	1607.	15.330	693.	48.20	0.070	1	CRUISE
12	6.70	1.450	61.05	90.22	2419.00	3325.00	3486.00	1912.	14.060	804.	60.40	0.075	1	CRUISE
13	7.00	1.450	66.14	90.50	3076.00	4228.00	4443.00	2263.	12.870	910.	74.11	0.081	1	CRUISE
14	7.10	1.450	71.23	90.79	3848.00	5280.00	5564.00	2667.	11.760	994.	87.99	0.089	1	CRUISE
15	6.80	1.450	76.32	89.23	4725.00	6495.00	6738.00	3654.	9.195	1020.	114.30	0.112	2	CRUISE
16	6.10	1.450	81.40	20.51	5734.00	7882.00	8172.00	4708.	7.613	976.	131.20	0.134	1	MAIN
17	6.60	1.450	86.49	20.55	6878.00	9454.00	9816.00	5270.	7.226	1122.	159.50	0.141	1	MAIN
18	7.20	1.450	91.58	20.58	8165.00	11220.00	11670.00	5830.	6.857	1296.	192.60	0.149	1	MAIN
19	7.70	1.450	96.67	20.62	9603.00	13200.00	13750.00	6542.	6.505	1463.	228.80	0.156	1	MAIN
20	8.90	1.450	101.80	20.66	11200.00	15380.00	16060.00	7259.	6.172	1780.	293.00	0.165	1	MAIN
21	7.50	1.450	106.80	20.69	12970.00	17820.00	18620.00	8033.	5.856	1575.	272.00	0.173	1	MAIN
22	4.30	1.450	111.90	20.36	14910.00	20490.00	21090.00	10190.	4.838	946.	197.80	0.209	2	MAIN
23	1.50	1.450	117.00	20.38	17050.00	23410.00	24120.00	11120.	4.635	345.	75.22	0.218	2	MAIN
24	1.30	1.450	122.10	20.40	19350.00	26600.00	27430.00	12110.	4.438	312.	70.99	0.228	2	MAIN
25	0.70	1.450	127.20	20.42	21870.00	30070.00	31030.00	13160.	4.248	175.	41.57	0.238	2	MAIN
26	0.50	1.450	132.30	20.44	24610.00	33820.00	34930.00	14330.	4.065	130.	32.26	0.248	2	MAIN
27	0.40	1.450	137.40	20.46	27560.00	37880.00	39150.00	15560.	3.898	108.	28.00	0.259	2	MAIN
28	0.20	1.450	142.70	20.49	32130.00	44400.00	46030.00	19240.	3.260	84.	25.95	0.309	3	MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	87.	29.04	0.334	3	MAIN
30	0.30	1.450	156.50	20.57	42950.00	60010.00	62400.00	24120.	2.787	90.	32.49	0.361	3	MAIN
31	0.30	1.450	163.00	20.59	49290.00	69240.00	71990.00	28860.	2.406	93.	38.85	0.418	4	MAIN
32	0.30	1.450	169.60	20.59	56300.00	79530.00	82810.00	32150.	2.230	96.	43.27	0.451	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10250.	HP
TURBINE POWER..	10630.	HP
TURBINE FUEL...	5033.	LBS/HR (0.144 TONS/MILE)
PROPULSION FUEL	5194.	LBS/HR (0.147 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	8. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	130. KW
TOTAL LOAD..	139. KW (111.5 LBS/HR)

(C-3)

ELECTRIC DRIVE SYSTEM

REF.NO. 1

MISSION PROFILE SUMMARY - MAIN ONLY - NEAREST 10 PERCENT MAGNET FIELD

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.036	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.39	24.96	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.54	37.80	51.96	61.69	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.72	89.60	123.20	132.90	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	30.15	175.00	240.50	248.80	1102.	10.160	60.	6.34	0.106	1 MAIN
6	1.20	1.450	30.53	30.21	302.40	415.70	429.20	1238.	10.860	72.	7.06	0.098	1 MAIN
7	1.20	1.450	35.61	30.26	480.20	660.10	681.00	1397.	11.230	84.	7.92	0.094	1 MAIN
8	1.20	1.450	40.70	30.32	716.80	985.30	1016.00	1581.	11.340	96.	8.90	0.093	1 MAIN
9	1.20	1.450	45.79	30.37	1021.00	1403.00	1448.00	1791.	11.260	108.	10.03	0.093	1 MAIN
10	1.20	1.450	50.88	30.43	1400.00	1924.00	1987.00	2030.	11.040	120.	11.31	0.094	1 MAIN
11	6.30	1.450	55.97	30.49	1863.00	2561.00	2647.00	2299.	10.720	693.	66.98	0.097	1 MAIN
12	6.70	1.450	61.05	30.54	2419.00	3325.00	3440.00	2602.	10.380	804.	80.31	0.100	1 MAIN
13	7.00	1.450	66.14	30.60	3076.00	4228.00	4378.00	2941.	9.901	910.	94.51	0.104	1 MAIN
14	7.10	1.450	71.23	30.65	3842.00	5280.00	5475.00	3319.	9.449	994.	107.90	0.109	1 MAIN
15	6.80	1.450	76.32	30.71	4725.00	6495.00	6742.00	3739.	8.986	1020.	116.10	0.114	1 MAIN
16	6.10	1.450	81.40	30.76	5734.00	7882.00	8193.00	4206.	8.522	976.	116.90	0.120	1 MAIN
17	6.60	1.450	86.49	30.82	6878.00	9454.00	9841.00	4723.	8.063	1122.	141.70	0.126	1 MAIN
18	7.20	1.450	91.58	30.87	8165.00	11220.00	11700.00	5295.	7.615	1296.	173.00	0.134	1 MAIN
19	7.70	1.450	96.67	30.93	9603.00	13200.00	13780.00	5929.	7.179	1463.	206.90	0.141	1 MAIN
20	8.90	1.450	101.80	30.98	11200.00	15390.00	16100.00	6630.	6.757	1780.	267.10	0.150	1 MAIN
21	7.50	1.450	106.80	31.04	12970.00	17820.00	18660.00	7405.	6.352	1575.	251.10	0.159	1 MAIN
22	4.30	1.450	111.90	31.10	14910.00	20490.00	21490.00	8264.	5.963	946.	160.50	0.170	1 MAIN
23	1.50	1.450	117.00	26.20	17030.00	23410.00	24180.00	10830.	4.758	345.	73.13	0.212	2 MAIN
24	1.30	1.450	122.10	26.23	19350.00	26600.00	27490.00	11860.	4.534	312.	69.37	0.222	2 MAIN
25	0.70	1.450	127.20	22.97	21870.00	30070.00	31050.00	12950.	4.324	175.	40.77	0.233	2 MAIN
26	0.50	1.450	132.30	22.99	24610.00	33820.00	34960.00	14110.	4.126	130.	31.72	0.244	2 MAIN
27	0.40	1.450	137.40	23.02	27560.00	37880.00	39180.00	15360.	3.938	108.	27.61	0.256	2 MAIN
28	0.30	1.450	143.70	20.48	32130.00	44400.00	46030.00	19340.	3.260	84.	25.92	0.309	3 MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	87.	29.00	0.333	3 MAIN
30	0.30	1.450	156.50	20.57	42950.00	60010.00	62400.00	24120.	2.787	90.	32.46	0.361	3 MAIN
31	0.30	1.450	163.00	18.49	49290.00	68240.00	71920.00	28850.	2.407	93.	38.81	0.417	4 MAIN
32	0.30	1.450	169.60	18.53	56300.00	79520.00	82730.00	32040.	2.237	96.	43.09	0.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10650.	HP
TURBINE FUEL...	4999.	LBS/HR (0.142 TONS/MILE)
PROPULSION FUEL	5087.	LBS/HR (0.144 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	100.	KW
TOTAL LOAD..	110.	KW (87.7 LBS/HR)

ELECTRIC DRIVE SYSTEM REF.NO. 1

MISSION PROFILE SUMMARY - MAIN + CRUISE - NEAREST 10 PERCENT MAGNET FIELD

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	PER THOUSAND HOURS FUEL RATE (PPH)	RANGE (NM/TON)	NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	1.450	5.09	686.00	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1	CRUISE
2	1.20	1.450	10.18	326.00	11.20	15.39	18.88	360.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.450	15.26	177.40	37.80	51.96	55.62	360.	18.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.450	20.35	113.10	89.60	123.20	128.40	405.	22.090	48.	2.73	0.057	1	CRUISE
5	1.20	1.450	25.44	113.50	175.00	240.20	250.30	492.	22.760	60.	3.29	0.053	1	CRUISE
6	1.20	1.450	30.53	113.80	302.40	415.70	432.30	599.	22.430	72.	3.77	0.052	1	CRUISE
7	1.20	1.450	35.61	114.20	480.20	660.10	686.80	738.	21.480	84.	4.47	0.053	1	CRUISE
8	1.20	1.450	40.70	114.50	716.80	985.30	1026.00	887.	20.200	96.	5.32	0.055	1	CRUISE
9	1.20	1.450	45.79	114.80	1021.00	1403.00	1464.00	1075.	18.780	108.	6.33	0.059	1	CRUISE
10	1.20	1.450	50.88	115.30	1400.00	1924.00	2012.00	1299.	17.250	120.	7.53	0.063	1	CRUISE
11	6.30	1.450	55.97	115.60	1863.00	2561.00	2683.00	1564.	15.760	693.	46.99	0.068	1	CRUISE
12	6.70	1.450	61.05	101.80	2419.00	3325.00	3488.00	1877.	14.320	804.	59.36	0.074	1	CRUISE
13	7.00	1.450	66.14	101.80	3076.00	4228.00	4446.00	2232.	13.050	910.	73.14	0.080	1	CRUISE
14	7.10	1.450	71.23	80.78	3842.00	5280.00	5564.00	2667.	11.760	994.	87.96	0.089	1	CRUISE
15	6.80	1.450	76.32	69.23	4725.00	6495.00	6738.00	3654.	9.195	1050.	114.20	0.112	2	CRUISE
16	6.10	1.450	81.40	60.45	5734.00	7882.00	8182.00	4202.	8.530	976.	117.40	0.120	2	CRUISE
17	6.60	1.450	86.49	50.82	6878.00	9454.00	9841.00	4723.	8.063	1122.	142.40	0.127	1	MAIN
18	7.20	1.450	91.58	30.87	8165.00	11220.00	11700.00	5295.	7.615	1296.	173.80	0.134	1	MAIN
19	7.70	1.450	96.67	30.93	9603.00	13200.00	13730.00	5929.	7.179	1468.	207.70	0.142	1	MAIN
20	8.00	1.450	101.80	30.58	11200.00	15390.00	16100.00	6680.	6.757	1700.	266.00	0.151	1	MAIN
21	7.50	1.450	106.80	31.04	12970.00	17820.00	18660.00	7405.	6.352	1575.	251.90	0.160	1	MAIN
22	4.30	1.450	111.90	31.10	14910.00	20480.00	21490.00	8264.	5.968	946.	161.00	0.170	1	MAIN
23	1.50	1.450	117.00	26.20	17030.00	23410.00	24180.00	10030.	4.758	345.	73.30	0.212	2	MAIN
24	1.30	1.450	122.10	26.23	19350.00	26600.00	27490.00	11060.	4.594	312.	69.51	0.223	2	MAIN
25	0.70	1.450	127.20	22.97	21870.00	30070.00	31050.00	12950.	4.324	175.	40.85	0.233	2	MAIN
26	0.50	1.450	132.30	22.99	24610.00	33820.00	34960.00	14110.	4.128	130.	31.77	0.244	2	MAIN
27	0.40	1.450	137.40	23.02	27560.00	37880.00	39180.00	15360.	3.938	108.	27.65	0.256	2	MAIN
28	0.30	1.450	142.70	20.49	32130.00	44400.00	46070.00	19240.	3.260	84.	25.95	0.309	3	MAIN
29	0.30	1.450	150.10	20.53	37350.00	51730.00	53730.00	21540.	3.015	87.	29.04	0.334	3	MAIN
30	0.30	1.450	158.50	20.57	43950.00	60010.00	62400.00	24120.	2.787	90.	32.49	0.361	3	MAIN
31	0.30	1.450	163.00	18.49	46290.00	69240.00	71920.00	28850.	2.407	93.	38.84	0.418	4	MAIN
32	0.30	1.450	169.60	18.53	56300.00	79520.00	82730.00	32040.	2.237	96.	43.13	0.449	4	MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10670.	HP
TURBINE FUEL...	4720.	LBS/HR (0.134 TONS/MILE)
PROPULSION FUEL	4832.	LBS/HR (0.137 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	130.	KW
TOTAL LOAD..	140.	KW (112.0 LBS/HR)

ELECTRIC DRIVE SYSTEM

REF.NO. 1

MISSION PROFILE SUMMARY - MAIN ONLY - FIXED FIELDS

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	PER THOUSAND HOURS TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.036	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	145.40	11.20	15.39	24.96	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	97.54	37.80	51.96	61.69	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.72	89.60	123.20	132.90	1100.	8.145	48.	6.23	0.132	1 MAIN
5	1.20	1.450	25.43	30.15	175.00	240.50	248.80	1102.	10.160	60.	6.34	0.106	1 MAIN
6	1.70	1.450	30.52	30.21	302.40	415.70	429.20	1236.	10.860	72.	7.06	0.098	1 MAIN
7	1.20	1.450	35.61	30.26	480.20	660.10	681.00	1397.	11.230	84.	7.92	0.094	1 MAIN
8	1.20	1.450	40.70	30.32	716.80	985.30	1016.00	1581.	11.340	96.	8.90	0.093	1 MAIN
9	1.20	1.450	45.78	30.37	1021.00	1403.80	1449.00	1791.	11.260	108.	10.03	0.093	1 MAIN
10	1.20	1.450	50.86	30.43	1400.00	1924.00	1987.00	2030.	11.040	120.	11.51	0.094	1 MAIN
11	8.30	1.450	55.97	30.49	1863.00	2561.00	2647.00	2799.	10.720	693.	66.96	0.097	1 MAIN
12	6.70	1.450	61.05	30.54	2419.00	3325.00	3440.00	2602.	10.330	804.	80.31	0.100	1 MAIN
13	7.00	1.450	66.14	30.60	3076.00	4228.00	4378.00	2941.	9.901	910.	94.51	0.104	1 MAIN
14	7.10	1.450	71.23	30.65	3842.00	5280.00	5475.00	3319.	9.449	994.	107.90	0.109	1 MAIN
15	6.00	1.450	76.32	30.71	4725.00	6495.00	6742.00	3739.	8.996	1020.	116.10	0.114	1 MAIN
16	6.10	1.450	81.40	30.76	5734.00	7882.00	8193.00	4206.	8.522	976.	116.90	0.120	1 MAIN
17	5.60	1.450	86.49	30.82	6878.00	9454.00	9841.00	4723.	8.063	1122.	141.70	0.126	1 MAIN
18	7.20	1.450	91.58	30.87	8163.00	11220.00	11700.00	5295.	7.615	1296.	173.00	0.134	1 MAIN
19	7.70	1.450	96.67	30.93	9603.00	13200.00	13780.00	5929.	7.179	1463.	206.90	0.141	1 MAIN
20	8.90	1.450	101.80	30.98	11200.00	15390.00	16100.00	6630.	6.757	1780.	267.10	0.150	1 MAIN
21	7.50	1.450	106.80	31.04	12970.00	17820.00	18660.00	7405.	6.352	1575.	251.10	0.159	1 MAIN
22	4.30	1.450	111.93	31.10	14910.00	20490.00	21490.00	8264.	5.963	946.	160.50	0.170	1 MAIN
23	1.50	1.450	117.00	24.45	17030.00	23410.00	24160.00	10820.	4.761	345.	73.09	0.212	2 MAIN
24	1.30	1.450	122.10	24.48	19350.00	26600.00	27470.00	11830.	4.545	313.	69.21	0.222	2 MAIN
25	0.70	1.450	127.20	24.50	21870.00	30070.00	31070.00	12920.	4.334	175.	40.68	0.232	2 MAIN
26	0.50	1.450	132.30	24.53	24610.00	33820.00	34980.00	14100.	4.130	130.	31.70	0.244	2 MAIN
27	0.40	1.450	137.40	24.55	27560.00	37880.00	39200.00	15380.	3.932	108.	27.65	0.256	2 MAIN
28	0.30	1.450	142.70	20.49	32130.00	44400.00	46030.00	19240.	3.260	84.	25.92	0.309	3 MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	87.	29.00	0.333	3 MAIN
30	0.30	1.450	156.50	20.57	43850.00	60010.00	62400.00	24120.	2.797	90.	32.46	0.361	3 MAIN
31	0.30	1.450	163.00	20.55	49200.00	69240.00	71990.00	28860.	2.406	93.	38.82	0.417	4 MAIN
32	0.30	1.450	169.60	20.59	56300.00	79520.00	82810.00	32150.	2.230	96.	43.24	0.450	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS	
EFFECTIVE POWER	7428.	HP	
SHAFT POWER....	10230.	HP	
TURBINE POWER..	10650.	HP	
TURBINE FUEL...	4999.	LBS/HR	(0.142 TONS/MILE)
PROPULSION FUEL	5087.	LBS/HR	(0.144 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	100. KW
TOTAL LOAD..	110. KW (87.7 LBS/HR)

ELECTRIC DRIVE SYSTEM REF.NO. 1

MISSION PROFILE SUMMARY - MAIN + CRUISE - FIXED FIELDS

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES	
1	1.10	1.450	5.09	686.10	1.40	1.92	5.19	380.	6.222	11.	2.28	0.208	1	CRUISE
2	1.20	1.450	10.18	326.10	11.20	15.39	18.88	380.	12.440	24.	2.49	0.104	1	CRUISE
3	1.20	1.450	15.26	177.70	37.80	51.96	55.63	360.	18.670	36.	2.49	0.069	1	CRUISE
4	1.20	1.450	20.35	87.96	89.60	123.20	127.90	409.	21.380	48.	2.76	0.057	1	CRUISE
5	1.20	1.450	25.44	88.24	175.00	240.50	244.40	502.	22.300	60.	3.25	0.054	1	CRUISE
6	1.20	1.450	30.53	88.52	302.40	415.70	431.00	617.	21.790	72.	3.87	0.054	1	CRUISE
7	1.20	1.450	35.61	88.81	460.20	660.10	685.00	756.	20.750	84.	4.61	0.055	1	CRUISE
8	1.20	1.450	40.70	89.09	716.80	985.30	1024.00	921.	19.480	96.	5.50	0.057	1	CRUISE
9	1.20	1.450	45.79	89.37	1021.00	1403.00	1461.00	1119.	18.070	108.	6.54	0.061	1	CRUISE
10	1.20	1.450	50.88	89.65	1400.00	1924.00	2008.00	1343.	16.680	120.	7.76	0.065	1	CRUISE
11	6.30	1.450	55.97	89.94	1862.00	2561.00	2679.00	1607.	15.330	693.	48.20	0.070	1	CRUISE
12	6.70	1.450	61.05	90.22	2419.00	3325.00	3486.00	1912.	14.060	804.	60.48	0.075	1	CRUISE
13	7.00	1.450	66.14	90.50	3076.00	4226.00	4443.00	2263.	12.870	910.	74.11	0.081	1	CRUISE
14	7.10	1.450	71.23	90.79	3842.00	5280.00	5564.00	2667.	11.760	994.	87.99	0.089	1	CRUISE
15	6.80	1.450	76.32	89.23	4725.00	6495.00	6736.00	3654.	9.195	1020.	114.30	0.112	2	CRUISE
16	6.10	1.450	81.40	90.76	5754.00	7882.00	8193.00	4206.	8.522	976.	117.50	0.120	1	MAIN
17	6.60	1.450	86.49	90.82	6878.00	9454.00	9841.00	4723.	8.063	1122.	142.40	0.127	1	MAIN
18	7.20	1.450	91.58	90.87	8165.00	11220.00	11700.00	5295.	7.615	1296.	173.80	0.134	1	MAIN
19	7.70	1.450	96.67	90.93	9603.00	13200.00	13780.00	5929.	7.179	1463.	207.70	0.142	1	MAIN
20	8.90	1.450	101.80	90.98	11200.00	15390.00	16100.00	6630.	6.757	1780.	268.00	0.151	1	MAIN
21	7.50	1.450	106.80	91.04	12970.00	17820.00	18680.00	7405.	6.352	1575.	251.90	0.160	1	MAIN
22	4.30	1.450	111.90	91.10	14910.00	20490.00	21490.00	8264.	5.963	946.	161.00	0.170	1	MAIN
23	1.50	1.450	117.00	24.45	17030.00	23410.00	24560.00	10820.	4.751	345.	73.25	0.212	2	MAIN
24	1.30	1.450	122.10	24.46	19350.00	26600.00	27470.00	11830.	4.545	312.	69.35	0.222	2	MAIN
25	0.70	1.450	127.20	24.50	21870.00	30070.00	31070.00	12920.	4.334	175.	40.76	0.233	2	MAIN
26	0.50	1.450	132.30	24.53	24610.00	33820.00	34980.00	14100.	4.130	130.	31.75	0.244	2	MAIN
27	0.40	1.450	137.40	24.55	27560.00	37860.00	38200.00	15380.	3.932	108.	27.69	0.256	2	MAIN
28	0.30	1.450	142.70	20.49	32150.00	44400.00	46050.00	19240.	3.260	84.	25.95	0.309	3	MAIN
29	0.30	1.450	150.10	20.53	37250.00	51750.00	53730.00	21540.	3.015	87.	29.04	0.334	3	MAIN
30	0.30	1.450	156.50	20.57	42550.00	60010.00	62400.00	24120.	2.737	90.	32.49	0.361	3	MAIN
31	0.30	1.450	163.00	20.55	48290.00	66240.00	71990.00	28860.	2.406	93.	38.85	0.418	4	MAIN
32	0.30	1.450	169.60	20.59	56300.00	79520.00	82810.00	32150.	2.230	96.	43.27	0.451	4	MAIN

C-35

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7428.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10670.	HP
TURBINE FUEL...	4729.	LBS/HR (0.134 TONS/MILE)
PROPULSION FUEL	4641.	LBS/HR (0.137 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	9.	KW
GENERATOR LUBE SYSTEM	1.	KW
HELIUM COMPRESSORS...	130.	KW
TOTAL LOAD..	140.	KW (112.0 LBS/HR)

***** RUN TERMINATED AFTER 146 SPEED CALCULATIONS

ELECTRIC DRIVE SYSTEM

REF.NO. 501- I

MISSION PROFILE SUMMARY - SINGLE CRUISE TURBINE

KTS	POT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	686.10	1.40	1.92	5.19	360.	6.222	11.	2.28	0.208	1 CRUISE
2	1.20	1.450	10.18	376.20	11.20	15.39	16.88	360.	13.440	24.	2.49	0.104	1 CRUISE
3	1.20	1.450	15.26	177.70	37.80	51.96	55.63	360.	16.670	36.	2.49	0.069	1 CRUISE
4	1.20	1.450	20.35	108.80	89.60	123.20	128.30	405.	22.110	48.	2.73	0.057	1 CRUISE
5	1.20	1.450	25.44	114.70	175.00	240.60	250.30	492.	22.760	60.	3.20	0.053	1 CRUISE
6	1.20	1.450	30.53	113.20	302.40	415.70	432.50	589.	22.440	72.	3.77	0.052	1 CRUISE
7	1.20	1.450	35.61	119.60	480.20	660.10	687.20	729.	21.500	84.	4.47	0.053	1 CRUISE
8	1.20	1.450	40.70	119.20	716.60	985.30	1027.00	887.	20.210	96.	5.31	0.055	1 CRUISE
9	1.20	1.450	45.79	117.70	1021.00	1403.00	1464.00	1075.	18.760	108.	6.32	0.059	1 CRUISE
10	1.20	1.450	50.88	115.30	1400.00	1924.00	2012.00	1299.	17.050	120.	7.53	0.063	1 CRUISE
11	6.30	1.450	55.97	112.20	1863.00	2561.00	2687.00	1568.	15.770	693.	46.05	0.066	1 CRUISE
12	6.70	1.450	61.05	108.70	2419.00	3325.00	3492.00	1872.	14.360	804.	59.20	0.074	1 CRUISE
13	7.00	1.450	66.14	105.00	3076.00	4228.00	4447.00	2231.	13.050	910.	73.10	0.080	1 CRUISE

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

PERFORMANCE AVERAGES OVER MISSION PROFILE (319 HOURS)

SPEED.....	9.61	KNOTS
EFFECTIVE POWER	1710.	HP
SHAFT POWER....	2351.	HP
TURBINE POWER..	2467.	HP
TURBINE FUEL...	1437.	LBS/HR (0.067 TONS/MILE)
PROPULSION FUEL	1543.	LBS/HR (0.072 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	1. KW
GENERATOR LUBE SYSTEM	0. KW
HELIUM COMPRESSORS...	130. KW
TOTAL LOAD..	131. KW (104.8 LBS/HR)

96-1

REF.NO. 501- 1

SINGLE CRUISE TURBINE

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
1 CRUISE	1.00	5.09	0.99	398.86	244.87	1.4500	72.75	0.41	91.09	0.27	78.40	100.00	8.31	92.27	LF
1 CRUISE	2.00	10.18	3.97	865.84	282.71	1.4500	72.75	2.72	94.70	1.87	85.09	92.43	16.64	357.27	LF
1 CRUISE	3.00	15.26	8.94	1515.32	336.13	1.4500	72.75	7.64	95.61	5.31	89.28	79.48	24.98	795.02	LF
1 CRUISE	4.00	20.35	15.89	2216.73	405.31	1.4500	72.75	14.96	96.07	10.44	108.78	72.77	33.34	1405.51	
1 CRUISE	5.00	25.44	24.83	2921.29	492.08	1.4500	72.75	24.83	96.09	16.80	114.84	69.16	41.71	2188.74	
1 CRUISE	6.00	30.53	35.76	3609.31	599.02	1.4500	72.75	34.11	95.11	23.85	118.23	67.36	50.09	3144.71	
1 CRUISE	7.00	35.61	48.67	4257.73	729.30	1.4500	72.75	44.51	93.95	31.10	119.55	66.85	58.48	4273.42	
1 CRUISE	8.00	40.70	63.57	4853.68	886.56	1.4500	72.75	54.71	95.35	38.19	119.25	67.24	66.89	5574.88	
1 CRUISE	9.00	45.79	80.45	5390.26	1074.88	1.4500	72.75	64.34	95.32	44.65	117.72	68.33	75.31	7049.07	
1 CRUISE	10.00	50.88	99.33	5866.31	1296.67	1.4500	72.75	73.17	95.56	50.92	115.23	69.99	83.74	8696.01	
1 CRUISE	11.00	55.97	120.18	6280.21	1552.65	1.4500	72.75	81.08	95.48	56.33	112.22	72.13	92.19	10515.69	
1 CRUISE	12.00	61.05	143.03	6636.72	1871.58	1.4500	72.75	88.08	95.28	61.05	108.74	74.97	100.65	12508.11	
1 CRUISE	13.00	66.14	167.88	6946.02	2230.81	1.4500	72.75	94.16	95.08	65.13	105.02	77.56	109.12	14673.26	
1 CRUISE	14.00	71.23	194.68	7207.92	2645.15	1.4500	72.75	99.41	94.86	68.60	101.19	80.74	117.61	17011.17	HS

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

C-27

SINGLE CRUISE TURBINE

REF.NO. 501- 1

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO.	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
1 CRUISE	1.00	5.09	0.99	3490.66	360.00	1.4500	72.75	0.68	37.10	0.18	686.09	11.43	8.31	92.27	
1 CRUISE	2.00	10.18	3.97	3319.76	360.00	1.4500	72.75	2.48	81.55	1.47	326.15	24.11	16.64	357.27	
1 CRUISE	3.00	15.26	8.94	2712.58	360.00	1.4500	72.75	7.30	93.40	4.96	177.72	44.40	24.98	795.02	
1 CRUISE	4.00	20.35	15.89	2213.73	405.21	1.4500	72.75	14.96	95.97	10.44	108.78	72.77	33.34	1405.51	
1 CRUISE	5.00	25.44	24.83	2621.29	492.08	1.4500	72.75	24.03	96.09	16.80	114.84	69.16	41.71	2186.74	
1 CRUISE	6.00	30.53	35.76	3609.31	599.02	1.4500	72.75	34.11	96.11	23.85	118.23	67.38	50.09	3144.71	
1 CRUISE	7.00	35.61	48.67	4257.73	729.30	1.4500	72.75	44.51	96.05	31.10	119.55	66.85	58.48	4273.42	
1 CRUISE	8.00	40.70	63.57	4853.68	886.56	1.4500	72.75	54.71	95.95	38.19	119.25	67.24	66.89	5374.85	
1 CRUISE	9.00	45.79	80.49	5390.26	1074.88	1.4500	72.75	64.34	95.82	44.85	117.72	68.33	75.31	7049.07	
1 CRUISE	10.00	50.88	99.33	5865.31	1298.69	1.4500	72.75	73.17	95.66	50.92	115.28	69.99	83.74	8696.01	
1 CRUISE	11.00	55.97	120.10	6280.21	1562.85	1.4500	72.75	81.09	95.48	56.33	112.22	72.13	92.19	10515.69	
1 CRUISE	12.00	61.05	143.03	6638.72	1871.68	1.4500	72.75	88.08	95.28	61.05	108.74	74.67	100.65	12500.11	
1 CRUISE	13.00	66.14	167.86	6946.02	2230.81	1.4500	72.75	94.16	95.08	65.13	105.02	77.56	109.12	14673.26	
1 CRUISE	14.00	71.23	194.69	7207.92	2645.16	1.4500	72.75	99.41	94.86	68.60	101.19	80.74	117.61	17011.17	HS

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

14 CARDS PRODUCED

ELECTRIC DRIVE SYSTEM REF.NO. 501- 2

MISSION PROFILE SUMMARY - TWO CRUISE TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	688.40	1.40	1.92	2.35	720.	3.111	11.	4.05	0.369	2 CRUISE
2	1.20	1.450	10.18	336.10	11.20	15.39	22.04	720.	6.222	24.	4.42	0.184	2 CRUISE
3	1.20	1.450	15.26	207.90	37.80	51.96	58.76	720.	9.333	36.	4.42	0.123	2 CRUISE
4	1.20	1.450	20.35	122.00	89.60	123.20	129.70	720.	12.440	48.	4.42	0.092	2 CRUISE
5	1.20	1.450	25.44	86.00	175.00	240.50	249.10	804.	13.920	60.	4.88	0.081	2 CRUISE
6	1.20	1.450	30.53	90.06	302.40	415.70	429.80	937.	14.360	72.	5.59	0.078	2 CRUISE
7	1.20	1.450	35.61	92.70	480.20	660.10	682.00	1095.	14.320	84.	6.43	0.077	2 CRUISE
8	1.20	1.450	40.70	94.19	716.80	985.30	1018.00	1279.	14.010	96.	7.42	0.077	2 CRUISE
9	1.20	1.450	45.79	94.72	1021.00	1403.00	1449.00	1495.	13.490	108.	8.58	0.079	2 CRUISE
10	1.20	1.450	50.88	94.49	1400.00	1924.00	1988.00	1744.	12.840	120.	9.91	0.083	2 CRUISE
11	6.30	1.450	55.97	93.63	1863.00	2561.00	2646.00	2031.	12.130	693.	60.14	0.087	2 CRUISE
12	6.70	1.450	61.05	92.28	2419.00	3325.00	3440.00	2361.	11.330	804.	73.84	0.092	2 CRUISE
13	7.00	1.450	66.14	90.57	3076.00	4230.00	4377.00	2738.	10.640	910.	88.94	0.098	2 CRUISE
14	7.10	1.450	71.23	88.58	3843.00	5280.00	5471.00	3166.	9.904	994.	103.80	0.104	2 CRUISE
15	6.80	1.450	76.32	86.39	4725.00	6495.00	6736.00	3651.	9.203	1020.	114.20	0.112	2 CRUISE
16	6.10	1.450	81.40	84.05	5734.00	7882.00	8184.00	4197.	8.540	976.	117.30	0.120	2 CRUISE
17	6.60	1.450	86.49	81.70	6878.00	9454.00	9828.00	4808.	7.919	1122.	145.00	0.129	2 CRUISE

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

PERFORMANCE AVERAGES OVER MISSION PROFILE (595 HOURS)

SPEED.....	12.27	KNOTS
EFFECTIVE POWER	3322.	HP
SHAFT POWER....	4086.	HP
TURBINE POWER..	4736.	HP
TURBINE FUEL...	2814.	LBS/HR (0.102 TONS/MILE)
PROPULSION FUEL	2921.	LBS/HR (0.106 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	2. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	130. KW
TOTAL LOAD..	133. KW (106.5 LBS/HR)

6-D

TWO CRUISE TURBINES

REF.NO. 501- 2

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE RPM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
2 CRUISE	1.00	5.09	0.99	398.26	481.40	1.4500	72.75	0.21	89.13	0.14	78.28	100.00	8.31	92.27	LF
2 CRUISE	2.00	10.18	3.97	796.00	552.64	1.4500	72.75	1.45	93.37	0.99	78.42	100.00	16.64	357.27	LF
2 CRUISE	3.00	15.26	8.94	1199.21	602.78	1.4500	72.75	4.25	95.59	2.96	78.57	100.00	24.98	795.02	LF
2 CRUISE	4.00	20.35	15.89	1603.31	693.26	1.4500	72.75	8.71	96.29	6.11	80.26	98.08	33.34	1405.51	LF
2 CRUISE	5.00	25.44	24.83	2138.32	804.45	1.4500	72.75	14.83	96.56	10.28	86.02	91.67	41.71	2188.74	
2 CRUISE	6.00	30.53	35.76	2749.35	937.53	1.4500	72.75	21.65	96.71	15.24	90.06	87.72	50.09	3144.71	
2 CRUISE	7.00	35.61	48.67	3301.55	1094.90	1.4500	72.75	29.42	96.78	20.72	92.70	85.38	58.48	4273.42	
2 CRUISE	8.00	40.70	63.57	3833.65	1279.49	1.4500	72.75	37.57	96.81	26.46	94.19	84.18	66.89	5574.88	
2 CRUISE	9.00	45.79	80.45	4367.44	1494.60	1.4500	72.75	45.80	96.81	32.26	94.72	83.86	75.31	7049.07	
2 CRUISE	10.00	50.88	99.33	4807.38	1743.91	1.4500	72.75	53.86	96.78	37.92	94.49	84.22	83.74	8696.01	
2 CRUISE	11.00	55.97	120.18	5240.19	2031.34	1.4500	72.75	61.57	96.73	43.33	93.63	85.15	92.19	10515.69	
2 CRUISE	12.00	61.05	143.03	5634.52	2361.29	1.4500	72.75	68.81	96.67	48.40	92.29	86.54	100.65	12508.11	
2 CRUISE	13.00	66.14	167.86	5990.48	2738.08	1.4500	72.75	75.51	96.60	53.06	90.57	88.34	109.12	14673.26	
2 CRUISE	14.00	71.23	194.68	6309.36	3166.38	1.4500	72.75	81.62	96.51	57.31	88.53	90.49	117.61	17011.17	
2 CRUISE	15.00	76.32	223.48	6593.23	3650.96	1.4500	72.75	87.15	96.42	61.13	86.39	92.95	126.11	19521.83	
2 CRUISE	16.00	81.40	254.27	6844.66	4196.67	1.4500	72.75	92.12	96.31	64.54	84.08	95.68	134.63	22205.21	
2 CRUISE	17.00	86.49	287.05	7066.57	4808.85	1.4500	72.75	96.54	96.20	67.57	81.70	98.64	143.15	25061.31	
2 CRUISE	18.00	91.58	321.82	7263.66	5493.09	1.4500	72.75	100.45	96.07	70.21	80.74	100.00	151.69	28090.16	HS

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

0/4-2

TWO CRUISE TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
2 CRUISE	1.00	5.09	0.99	3502.63	720.00	1.4500	72.75	0.55	23.04	0.09	688.44	11.37	8.31	92.27	
2 CRUISE	2.00	10.18	3.97	3419.57	720.00	1.4500	72.75	1.45	69.84	0.73	336.06	23.34	16.64	357.27	
2 CRUISE	3.00	15.26	8.94	3172.57	720.00	1.4500	72.75	3.86	88.42	2.48	207.86	37.80	24.98	795.02	
2 CRUISE	4.00	20.35	15.89	2483.51	720.00	1.4500	72.75	8.51	94.98	5.88	122.03	64.50	33.34	1405.51	
2 CRUISE	5.00	25.44	24.83	2188.32	804.46	1.4500	72.75	14.63	96.56	10.28	86.02	91.67	41.71	2188.74	
2 CRUISE	6.00	30.53	35.76	2749.35	937.53	1.4500	72.75	21.66	96.71	15.24	90.06	87.72	50.09	3144.71	
2 CRUISE	7.00	35.61	48.67	3301.55	1094.90	1.4500	72.75	29.42	96.78	20.72	92.70	85.38	58.48	4273.42	
2 CRUISE	8.00	40.70	63.57	3833.65	1279.49	1.4500	72.75	37.57	96.81	26.46	94.19	84.18	66.80	5574.88	
2 CRUISE	9.00	45.79	80.45	4337.44	1494.60	1.4500	72.75	45.80	96.81	32.26	94.72	83.86	75.31	7049.07	
2 CRUISE	10.00	50.88	99.33	4807.38	1743.90	1.4500	72.75	53.86	96.78	37.92	94.49	84.22	83.74	8696.01	
2 CRUISE	11.00	55.97	120.18	5240.19	2031.39	1.4500	72.75	61.57	96.73	43.33	93.63	85.15	92.19	10515.69	
2 CRUISE	12.00	61.05	143.03	5634.52	2361.29	1.4500	72.75	68.81	96.67	48.40	92.29	86.54	100.65	12508.11	
2 CRUISE	13.00	66.14	167.86	5990.48	2738.08	1.4500	72.75	75.51	96.60	53.06	90.57	88.34	109.12	14673.26	
2 CRUISE	14.00	71.23	194.68	6309.36	3166.38	1.4500	72.75	81.62	96.51	57.31	88.56	90.49	117.61	17011.17	
2 CRUISE	15.00	76.32	223.48	6593.23	3650.96	1.4500	72.75	87.15	96.42	61.13	86.39	92.95	126.11	19521.83	
2 CRUISE	16.00	81.40	254.27	6844.68	4196.67	1.4500	72.75	92.12	96.31	64.54	84.06	95.68	134.63	22205.21	
2 CRUISE	17.00	86.49	287.05	7066.57	4808.45	1.4500	72.75	96.54	96.20	67.57	81.70	98.64	143.15	25061.31	
2 CRUISE	18.00	91.58	321.82	7393.88	5493.09	1.4500	72.75	100.45	96.07	70.21	80.74	100.00	151.69	28090.16	HS

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

18 CARDS PRODUCED

ELECTRIC DRIVE SYSTEM

MISSION PROFILE SUMMARY - ONE MAIN TURBINE

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.10	1.40	1.92	11.27	1100.	2.036	11.	5.80	0.527	1 MAIN
2	1.20	1.450	10.18	143.40	11.20	15.39	24.96	1100.	4.073	24.	6.33	0.264	1 MAIN
3	1.20	1.450	15.26	91.59	37.80	51.96	61.70	1100.	6.109	36.	6.33	0.176	1 MAIN
4	1.20	1.450	20.35	61.81	89.60	123.20	132.90	1100.	8.145	48.	6.33	0.132	1 MAIN
5	1.20	1.450	25.44	29.50	175.00	240.50	248.70	1102.	10.170	60.	6.34	0.106	1 MAIN
6	1.20	1.450	30.53	31.26	302.40	415.70	429.40	1238.	10.860	72.	7.06	0.098	1 MAIN
7	1.20	1.450	35.61	32.60	480.20	660.10	681.80	1395.	11.240	84.	7.91	0.094	1 MAIN
8	1.20	1.450	40.70	33.57	716.80	985.30	1018.00	1576.	11.370	96.	8.88	0.092	1 MAIN
9	1.20	1.450	45.79	34.23	1021.00	1403.00	1450.00	1763.	11.310	108.	9.99	0.092	1 MAIN
10	1.20	1.450	50.88	34.62	1400.00	1924.00	1991.00	2018.	11.100	120.	11.25	0.094	1 MAIN
11	6.30	1.450	55.97	34.79	1863.00	2561.00	2652.00	2284.	10.790	693.	66.54	0.096	1 MAIN
12	6.70	1.450	61.05	34.77	2419.00	3325.00	3446.00	2584.	10.400	804.	79.76	0.099	1 MAIN
13	7.00	1.450	66.14	34.58	3076.00	4228.00	4385.00	2921.	9.969	910.	93.84	0.103	1 MAIN
14	7.10	1.450	71.23	34.27	3842.00	5280.00	5482.00	3299.	9.506	994.	107.80	0.108	1 MAIN
15	6.80	1.450	76.32	33.84	4725.00	6495.00	6750.00	3721.	9.029	1020.	115.50	0.113	1 MAIN
16	6.10	1.450	81.40	33.33	5734.00	7882.00	8201.00	4191.	8.591	976.	116.50	0.119	1 MAIN
17	6.60	1.450	86.49	32.75	6878.00	9454.00	9843.00	4713.	8.079	1122.	141.40	0.126	1 MAIN
18	7.20	1.450	91.58	32.11	8168.00	11220.00	11700.00	5291.	7.621	1296.	172.90	0.133	1 MAIN
19	7.70	1.450	96.67	31.44	9606.00	13200.00	13780.00	5928.	7.179	1483.	206.90	0.141	1 MAIN
20	8.90	1.450	101.80	30.75	11200.00	15390.00	16100.00	6629.	6.758	1780.	267.00	0.150	1 MAIN
21	7.50	1.450	106.80	30.04	12970.00	17820.00	18660.00	7398.	6.359	1575.	250.80	0.159	1 MAIN
22	4.30	1.450	111.90	29.32	14910.00	20490.00	21480.00	8238.	5.982	946.	160.00	0.169	1 MAIN

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

24-D

PERFORMANCE AVERAGES OVER MISSION PROFILE (941 HOURS)

SPEED.....	15.13	KNOTS	
EFFECTIVE POWER	6250.	HP	
SHAFT POWER....	8590.	HP	
TURBINE POWER..	8963.	HP	
TURBINE FUEL...	4329.	LBS/HR	(0.128 TONS/MILE)
PROPULSION FUEL	4415.	LBS/HR	(0.130 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	7. KW
GENERATOR LUBE SYSTEM	1. KW
HELIUM COMPRESSORS...	100. KW
TOTAL LOAD..	108. KW (86.4 LBS/HR)

REF.NO. 501- 3

ONE MAIN TURBINE

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
1 MAIN	1.00	5.09	0.99	91.37	754.24	1.4500	72.75	0.11	91.21	0.07	17.96	100.00	8.31	92.27	LF
1 MAIN	2.00	10.18	3.97	207.33	811.63	1.4500	72.75	0.76	94.96	0.53	20.38	88.30	16.64	357.27	LF
1 MAIN	3.00	15.26	8.94	370.18	889.49	1.4500	72.75	1.32	96.04	1.62	24.25	74.32	24.98	795.02	LF
1 MAIN	4.00	20.35	15.89	553.73	986.11	1.4500	72.75	4.94	96.50	3.47	27.21	66.37	33.34	1405.51	LF
1 MAIN	5.00	25.44	24.83	750.43	1101.81	1.4500	72.75	8.61	96.71	6.06	29.50	61.33	41.71	2183.74	
1 MAIN	6.00	30.53	35.76	954.41	1237.60	1.4500	72.75	13.23	96.79	9.32	31.26	57.97	50.09	3144.71	
1 MAIN	7.00	35.61	48.67	1160.97	1395.02	1.4500	72.75	18.64	96.81	13.13	32.60	55.70	58.48	4273.42	
1 MAIN	8.00	40.70	63.57	1366.30	1575.97	1.4500	72.75	24.64	96.78	17.35	33.57	54.19	66.89	5574.88	
1 MAIN	9.00	45.79	80.45	1567.29	1782.67	1.4500	72.75	31.03	96.73	21.84	34.23	53.25	75.31	7049.07	
1 MAIN	10.00	50.88	99.33	1761.52	2017.64	1.4500	72.75	37.63	96.57	26.46	34.62	52.73	83.74	8696.01	
1 MAIN	11.00	55.97	120.18	1947.11	2283.66	1.4500	72.75	44.29	96.39	31.12	34.79	52.57	92.19	10515.69	
1 MAIN	12.00	61.05	143.03	2122.72	2583.73	1.4500	72.75	50.86	96.31	35.71	34.77	52.70	100.65	12508.11	
1 MAIN	13.00	66.14	167.86	2287.45	2921.07	1.4500	72.75	57.25	96.42	40.16	34.58	53.08	109.12	14673.26	
1 MAIN	14.00	71.23	194.68	2440.81	3299.08	1.4500	72.75	63.38	96.32	44.41	34.27	53.67	117.61	17011.17	
1 MAIN	15.00	76.32	223.48	2582.63	3721.32	1.4500	72.75	69.18	96.22	48.43	33.84	54.44	126.11	19521.83	
1 MAIN	16.00	81.40	254.27	2713.02	4191.49	1.4500	72.75	74.63	96.11	52.18	33.33	55.38	134.63	22205.21	
1 MAIN	17.00	86.49	287.05	2832.28	4713.41	1.4500	72.75	79.69	96.00	55.66	32.75	56.47	143.15	25061.31	
1 MAIN	18.00	91.58	321.82	2940.92	5290.98	1.4500	72.75	84.37	95.89	58.86	32.11	57.68	151.69	28090.16	
1 MAIN	19.00	96.67	358.57	3039.53	5928.21	1.4500	72.75	88.67	95.77	61.78	31.44	59.02	160.25	31291.80	
1 MAIN	20.00	101.76	397.30	3128.70	6629.11	1.4500	72.75	92.60	95.65	64.44	30.75	60.46	168.82	34666.17	
1 MAIN	21.00	106.84	438.03	3209.33	7397.77	1.4500	72.75	96.18	95.53	66.84	30.04	62.00	177.40	38213.25	
1 MAIN	22.00	111.93	480.74	3281.95	8238.31	1.4500	72.75	99.44	95.40	69.01	29.32	63.63	185.99	41933.10	
1 MAIN	23.00	117.02	525.43	3347.31	9154.85	1.4500	72.75	102.39	95.27	70.96	28.60	65.34	194.60	45825.68	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

C-43

ONE MAIN TURBINE

REF.NO. 501-.3

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
1 MAIN	1.00	5.09	0.99	1481.14	1100.00	1.4500	72.75	0.39	17.07	0.05	291.12	6.17	8.31	92.27	
1 MAIN	2.00	10.18	3.97	1459.49	1100.00	1.4500	72.75	0.87	61.67	0.39	143.43	12.54	16.64	357.27	
1 MAIN	3.00	15.26	8.94	1397.97	1100.00	1.4500	72.75	2.14	84.22	1.31	91.59	18.68	24.98	795.02	
1 MAIN	4.00	20.35	15.89	1257.96	1100.00	1.4500	72.75	4.61	92.68	3.11	61.81	29.21	33.34	1405.51	
1 MAIN	5.00	25.44	24.83	750.43	1101.81	1.4500	72.75	8.61	96.71	6.06	29.50	61.33	41.71	2188.74	
1 MAIN	6.00	30.53	35.76	954.41	1237.60	1.4500	72.75	13.23	96.79	9.32	31.26	57.97	50.09	3144.71	
1 MAIN	7.00	35.61	48.67	1160.97	1395.02	1.4500	72.75	18.64	96.81	13.13	32.60	55.70	58.48	4273.42	
1 MAIN	8.00	40.70	63.57	1366.30	1575.97	1.4500	72.75	24.64	96.78	17.35	33.57	54.19	66.89	5574.88	
1 MAIN	9.00	45.79	80.45	1567.29	1782.67	1.4500	72.75	31.03	96.73	21.84	34.23	53.25	75.31	7049.07	
1 MAIN	10.00	50.88	99.33	1761.52	2017.64	1.4500	72.75	37.63	96.67	26.46	34.62	52.73	83.74	8696.01	
1 MAIN	11.00	55.97	120.18	1947.11	2283.66	1.4500	72.75	44.29	96.59	31.12	34.79	52.57	92.19	10515.69	
1 MAIN	12.00	61.05	143.03	2122.72	2583.73	1.4500	72.75	50.86	96.51	35.71	34.77	52.70	100.65	12508.11	
1 MAIN	13.00	66.14	167.86	2287.45	2921.07	1.4500	72.75	57.25	96.42	40.16	34.58	53.09	109.12	14673.26	
1 MAIN	14.00	71.23	194.68	2440.81	3299.08	1.4500	72.75	63.38	96.32	44.41	34.27	53.67	117.61	17011.17	
1 MAIN	15.00	76.32	223.48	2582.63	3721.32	1.4500	72.75	69.18	96.22	48.43	33.84	54.44	126.11	19521.83	
1 MAIN	16.00	81.40	254.27	2713.02	4191.49	1.4500	72.75	74.63	96.11	52.18	33.33	55.38	134.63	22205.21	
1 MAIN	17.00	86.49	287.05	2832.28	4713.41	1.4500	72.75	79.69	96.00	55.66	32.75	56.47	143.15	25061.31	
1 MAIN	18.00	91.58	321.82	2940.92	5290.93	1.4500	72.75	84.37	95.89	58.86	32.11	57.68	151.69	28090.16	
1 MAIN	19.00	96.67	358.57	3039.53	5928.21	1.4500	72.75	88.67	95.77	61.78	31.44	59.02	160.25	31291.80	
1 MAIN	20.00	101.76	397.30	3128.76	6629.11	1.4500	72.75	92.60	95.65	64.44	30.75	60.46	168.82	34666.17	
1 MAIN	21.00	106.84	438.03	3209.33	7397.77	1.4500	72.75	96.18	95.53	66.84	30.04	62.00	177.40	38213.25	
1 MAIN	22.00	111.93	480.74	3281.95	8238.31	1.4500	72.75	99.44	95.40	69.01	29.32	63.63	185.99	41933.10	
1 MAIN	23.00	117.02	525.43	3347.31	9154.85	1.4500	72.75	102.39	95.27	70.96	28.60	65.34	194.60	45825.68	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

23 CARDS PRODUCED

ELECTRIC DRIVE SYSTEM

REF.NO. 501-4

MISSION PROFILE SUMMARY - TWO MAIN TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	PER THOUSAND HOURS: TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.40	1.40	1.92	20.53	2200.	1.018	11.	11.21	1.019	2 MAIN
2	1.20	1.450	10.18	144.70	11.20	15.39	34.28	2200.	2.036	24.	12.22	0.509	2 MAIN
3	1.20	1.450	15.26	94.50	37.90	51.96	71.05	2200.	3.055	36.	12.22	0.340	2 MAIN
4	1.20	1.450	20.35	67.87	89.60	123.20	142.20	2200.	4.073	48.	12.22	0.255	2 MAIN
5	1.20	1.450	25.44	49.74	175.00	240.50	259.10	2200.	5.091	60.	12.22	0.204	2 MAIN
6	1.20	1.450	30.53	33.15	302.40	415.70	432.50	2200.	6.109	72.	12.22	0.170	2 MAIN
7	1.20	1.450	35.61	24.21	480.20	660.10	679.20	2347.	6.680	84.	13.01	0.155	2 MAIN
8	1.20	1.450	40.70	25.19	716.80	985.30	1013.00	2577.	6.953	96.	14.25	0.148	2 MAIN
9	1.20	1.450	45.79	25.96	1021.00	1403.00	1442.00	2835.	7.111	108.	15.63	0.145	2 MAIN
10	1.20	1.450	50.89	26.56	1400.00	1924.00	1978.00	3122.	7.174	120.	17.17	0.143	2 MAIN
11	6.30	1.450	55.97	27.00	1863.00	2561.00	2632.00	3442.	7.159	693.	99.12	0.143	2 MAIN
12	6.70	1.450	61.05	27.31	2419.00	3325.00	3418.00	3795.	7.082	804.	116.00	0.144	2 MAIN
13	7.00	1.450	66.14	27.49	3076.00	4228.00	4346.00	4186.	6.957	910.	133.40	0.147	2 MAIN
14	7.10	1.450	71.23	27.56	3842.00	5280.00	5430.00	4616.	6.793	994.	149.00	0.150	2 MAIN
15	6.80	1.450	76.32	27.55	4725.00	6495.00	6680.00	5090.	6.602	1020.	157.10	0.154	2 MAIN
16	6.10	1.450	81.40	27.45	5734.00	7882.00	8110.00	5609.	6.390	976.	155.10	0.159	2 MAIN
17	6.60	1.450	86.49	27.28	6878.00	9454.00	9731.00	6177.	6.165	1122.	184.50	0.164	2 MAIN
18	7.20	1.450	91.58	27.05	8165.00	11220.00	11560.00	6798.	5.932	1296.	221.30	0.171	2 MAIN
19	7.70	1.450	96.67	26.77	9603.00	13200.00	13600.00	7474.	5.694	1463.	260.00	0.178	2 MAIN
20	8.90	1.450	101.80	26.45	11200.00	15390.00	15870.00	8211.	5.456	1780.	329.80	0.185	2 MAIN
21	7.50	1.450	106.80	26.09	12970.00	17820.00	18380.00	9011.	5.220	1575.	304.70	0.193	2 MAIN
22	4.30	1.450	111.90	25.71	14910.00	20490.00	21140.00	9878.	4.989	946.	191.40	0.202	2 MAIN
23	1.50	1.450	117.00	25.30	17030.00	23410.00	24170.00	10820.	4.763	345.	73.05	0.212	2 MAIN
24	1.30	1.450	122.10	24.88	19350.00	26600.00	27470.00	11830.	4.545	312.	69.20	0.222	2 MAIN
25	0.70	1.450	127.20	24.44	21870.00	30070.00	31070.00	12920.	4.334	175.	40.68	0.232	2 MAIN
26	0.50	1.450	132.30	24.00	24610.00	33820.00	34970.00	14090.	4.132	130.	31.68	0.244	2 MAIN
27	0.40	1.450	137.40	23.55	27560.00	37880.00	39190.00	15350.	3.939	108.	27.60	0.256	2 MAIN

* * INSUFFICIENT DATA FOR FULL MISSION PROFILE * * *

PERFORMANCE AVERAGES OVER MISSION PROFILE (985 HOURS)

SPEED.....	15.54	KNOTS	
EFFECTIVE POWER	6878.	HP	
SHAFT POWER....	9453.	HP	
TURBINE POWER..	9741.	HP	
TURBINE FUEL...	5999.	LBS/HR	(0.172 TONS/MILE)
PROPULSION FUEL	6085.	LBS/HR	(0.175 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	6. KW
GENERATOR LUBE SYSTEM	2. KW
HELIUM COMPRESSORS...	100. KW
TOTAL LOAD..	108. KW (96.1 LBS/HR)

REF.NO. 501- 4

TWO MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
2 MAIN	1.00	5.09	0.99	91.29	1495.34	1.4500	72.75	0.06	89.18	0.04	17.94	100.00	8.31	92.27	LF
2 MAIN	2.00	10.18	3.97	182.76	1573.07	1.4500	72.75	0.40	94.09	0.27	17.96	100.00	16.64	357.27	LF
2 MAIN	3.00	15.26	8.94	274.41	1677.85	1.4500	72.75	1.23	95.79	0.86	17.98	100.00	24.98	795.02	LF
2 MAIN	4.00	20.35	15.89	408.79	1809.38	1.4500	72.75	2.69	96.40	1.89	19.69	91.38	33.34	1405.51	LF
2 MAIN	5.00	25.44	24.83	547.29	1964.54	1.4500	72.75	4.82	96.85	3.40	21.51	83.74	41.71	2188.74	LF
2 MAIN	6.00	30.53	35.76	702.10	2143.54	1.4500	72.75	7.62	97.05	5.38	23.00	78.41	50.09	3144.71	LF
2 MAIN	7.00	35.61	48.67	862.24	2347.31	1.4500	72.75	11.04	97.18	7.80	24.21	74.56	58.48	4273.42	
2 MAIN	8.00	40.70	63.57	1025.17	2577.21	1.4500	72.75	14.99	97.25	10.61	25.19	71.74	66.80	5574.88	
2 MAIN	9.00	45.79	80.45	1188.79	2834.89	1.4500	72.75	19.40	97.23	13.73	25.96	69.67	75.31	7049.07	
2 MAIN	10.00	50.88	99.33	1351.28	3122.31	1.4500	72.75	24.16	97.30	17.10	26.56	68.17	83.74	8696.01	
2 MAIN	11.00	55.97	120.18	1511.12	3441.66	1.4500	72.75	29.17	97.30	20.65	27.00	67.12	92.19	10515.69	
2 MAIN	12.00	61.05	143.03	1667.07	3795.35	1.4500	72.75	34.35	97.20	24.31	27.31	66.44	100.65	12508.11	
2 MAIN	13.00	66.14	167.86	1818.08	4185.99	1.4500	72.75	39.60	97.27	28.02	27.49	66.06	109.12	14673.26	
2 MAIN	14.00	71.23	194.68	1963.37	4616.40	1.4500	72.75	44.86	97.25	31.74	27.56	65.95	117.61	17011.17	
2 MAIN	15.00	76.32	223.48	2102.30	5089.55	1.4500	72.75	50.05	97.22	35.41	27.55	66.05	126.11	19521.83	
2 MAIN	16.00	81.40	254.27	2234.45	5608.59	1.4500	72.75	55.15	97.19	39.00	27.45	66.36	134.63	22205.21	
2 MAIN	17.00	86.49	287.05	2359.53	6176.77	1.4500	72.75	60.09	97.16	42.47	27.28	66.83	143.16	25061.31	
2 MAIN	18.00	91.58	321.82	2477.40	6797.51	1.4500	72.75	64.84	97.12	45.81	27.05	67.46	151.69	28090.16	
2 MAIN	19.00	96.67	358.57	2588.05	7474.32	1.4500	72.75	69.33	97.08	49.00	26.77	68.24	160.25	31291.80	
2 MAIN	20.00	101.76	397.30	2691.53	8210.82	1.4500	72.75	73.70	97.03	52.03	26.45	69.13	168.82	34666.17	
2 MAIN	21.00	106.84	438.03	2788.03	9010.63	1.4500	72.75	77.73	96.99	54.88	26.09	70.15	177.40	38213.25	
2 MAIN	22.00	111.93	480.74	2877.75	9877.73	1.4500	72.75	81.62	96.94	57.56	25.71	71.27	185.99	41933.10	
2 MAIN	23.00	117.02	525.43	2960.98	10815.67	1.4500	72.75	85.22	96.89	60.07	25.30	72.48	194.60	45825.65	
2 MAIN	24.00	122.11	572.12	3038.03	11828.47	1.4500	72.75	88.53	96.83	62.40	24.88	73.79	203.22	49890.99	
2 MAIN	25.00	127.19	620.79	3109.22	12919.98	1.4500	72.75	91.72	96.78	64.58	24.44	75.18	211.85	54129.05	
2 MAIN	26.00	132.28	671.44	3174.92	14094.15	1.4500	72.75	94.63	96.72	66.59	24.00	76.[illegible]	220.50	58539.85	
2 MAIN	27.00	137.37	724.09	3235.46	15354.91	1.4500	72.75	97.34	96.66	68.45	23.55	78.[illegible]	229.16	63123.40	
2 MAIN	28.00	142.46	811.51	3315.97	17377.27	1.4500	72.36	100.96	96.53	70.52	23.08	79.94	240.05	70732.75	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

TWO MAIN TURBINES

REF.NO. 501- 4

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
2 MAIN	1.00	5.09	0.99	1482.72	2200.00	1.4500	72.75	0.36	9.37	0.02	291.43	6.16	8.31	92.27	
2 MAIN	2.00	10.18	3.97	1471.91	2200.00	1.4500	72.75	0.59	44.91	0.19	144.65	12.42	16.64	357.27	
2 MAIN	3.00	15.26	8.94	1442.35	2200.00	1.4500	72.75	1.23	73.12	0.66	94.50	19.03	24.98	795.02	
2 MAIN	4.00	20.35	15.89	1381.24	2200.00	1.4500	72.75	2.47	86.59	1.95	67.87	26.52	33.34	1405.51	
2 MAIN	5.00	25.44	24.83	1265.34	2200.00	1.4500	72.75	4.49	92.83	3.03	49.74	36.22	41.71	2188.74	
2 MAIN	6.00	30.53	35.76	1011.99	2200.00	1.4500	72.75	7.50	96.11	5.24	33.19	54.40	50.09	3144.71	
2 MAIN	7.00	35.61	48.67	862.24	2347.31	1.4500	72.75	11.04	97.18	7.80	24.21	74.56	58.48	4273.42	
2 MAIN	8.00	40.70	63.57	1025.17	2577.21	1.4500	72.75	14.99	97.25	10.61	25.19	71.74	66.89	5574.88	
2 MAIN	9.00	45.79	80.45	1188.79	2834.89	1.4500	72.75	19.40	97.28	13.73	25.96	69.67	75.31	7049.07	
2 MAIN	10.00	50.88	99.33	1351.28	3122.31	1.4500	72.75	24.16	97.30	17.10	26.56	68.17	83.74	8696.01	
2 MAIN	11.00	55.97	120.18	1511.12	3441.66	1.4500	72.75	29.17	97.30	20.65	27.00	67.12	92.19	10515.69	
2 MAIN	12.00	61.05	143.03	1667.07	3795.35	1.4500	72.75	34.35	97.29	24.31	27.31	66.44	100.65	12508.11	
2 MAIN	13.00	66.14	167.86	1818.08	4185.99	1.4500	72.75	39.60	97.27	28.02	27.49	66.06	109.12	14673.26	
2 MAIN	14.00	71.23	194.68	1963.37	4616.40	1.4500	72.75	44.86	97.25	31.74	27.56	65.95	117.61	17011.17	
2 MAIN	15.00	76.32	223.48	2102.30	5089.56	1.4500	72.75	50.06	97.22	35.41	27.55	66.05	126.11	19521.83	
2 MAIN	16.00	81.40	254.27	2234.45	5608.59	1.4500	72.75	55.15	97.19	39.00	27.45	66.36	134.63	22205.21	
2 MAIN	17.00	86.49	287.05	2359.53	6176.77	1.4500	72.75	60.09	97.16	42.47	27.28	66.83	143.15	25061.31	
2 MAIN	18.00	91.58	321.82	2477.40	6797.51	1.4500	72.75	64.84	97.12	45.81	27.05	67.46	151.69	28090.16	
2 MAIN	19.00	96.67	358.57	2588.05	7474.32	1.4500	72.75	69.38	97.08	49.00	26.77	68.24	160.25	31291.80	
2 MAIN	20.00	101.76	397.30	2691.53	8210.82	1.4500	72.75	73.70	97.03	52.03	26.45	69.13	168.82	34666.17	
2 MAIN	21.00	106.84	438.03	2788.03	9010.68	1.4500	72.75	77.78	96.99	54.88	26.09	70.15	177.40	38213.25	
2 MAIN	22.00	111.93	480.74	2877.75	9877.70	1.4500	72.75	81.62	96.94	57.56	25.71	71.27	185.99	41933.10	
2 MAIN	23.00	117.02	525.43	2960.98	10815.67	1.4500	72.75	85.22	96.89	60.07	25.30	72.48	194.60	45825.68	
2 MAIN	24.00	122.11	572.12	3038.03	11828.47	1.4500	72.75	88.58	96.83	62.40	24.88	73.79	203.22	49890.99	
2 MAIN	25.00	127.19	620.79	3109.22	12919.98	1.4500	72.75	91.72	96.78	64.58	24.44	75.18	211.85	54129.05	
2 MAIN	26.00	132.28	671.44	3174.92	14094.15	1.4500	72.75	94.63	96.72	66.59	24.00	76.64	220.50	58539.85	
2 MAIN	27.00	137.37	724.09	3235.46	15354.91	1.4500	72.75	97.34	96.66	68.45	23.55	78.18	229.16	63123.40	
2 MAIN	28.00	142.46	811.51	3315.97	17377.27	1.4500	72.36	100.96	96.53	70.52	23.08	79.94	240.05	70732.75	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

28 CARDS PRODUCED

ELECTRIC DRIVE SYSTEM

REF.NO. 501- 5

MISSION PROFILE SUMMARY - THREE MAIN TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	NAUT. MILES	TONS FUEL	TONS PER MILE	NO. OF TURBINES
							PER THOUSAND HOURS						
1	1.10	1.450	5.09	291.50	1.40	1.92	29.80	3300.	0.679	11.	16.61	1.510	3 MAIN
2	1.20	1.450	10.18	145.10	11.20	15.39	43.62	3300.	1.358	24.	18.12	0.755	3 MAIN
3	1.20	1.450	15.26	95.42	37.80	51.96	80.54	3300.	2.036	36.	18.12	0.503	3 MAIN
4	1.20	1.450	20.35	69.63	89.60	123.20	151.90	3300.	2.715	48.	18.12	0.378	3 MAIN
5	1.20	1.450	25.44	52.95	175.00	240.50	269.20	3300.	3.394	60.	18.12	0.302	3 MAIN
6	1.20	1.450	30.53	40.07	302.40	415.70	443.50	3300.	4.073	72.	18.12	0.252	3 MAIN
7	1.20	1.450	35.61	28.75	480.20	660.10	685.20	3300.	4.752	84.	18.12	0.216	3 MAIN
8	1.20	1.450	40.70	21.16	716.80	985.30	1015.00	3518.	5.094	96.	19.29	0.201	3 MAIN
9	1.20	1.450	45.79	21.92	1021.00	1403.00	1444.00	3917.	5.282	108.	20.89	0.193	3 MAIN
10	1.20	1.450	50.88	22.54	1400.00	1924.00	1981.00	4147.	5.401	120.	22.66	0.189	3 MAIN
11	6.30	1.450	55.97	23.04	1863.00	2561.00	2636.00	4511.	5.462	693.	129.20	0.186	3 MAIN
12	6.70	1.450	61.05	23.43	2419.00	3325.00	3423.00	4511.	5.473	804.	149.40	0.186	3 MAIN
13	7.00	1.450	66.14	23.72	3076.00	4228.00	4352.00	5349.	5.444	910.	169.80	0.187	3 MAIN
14	7.10	1.450	71.23	23.92	3842.00	5280.00	5437.00	5827.	5.382	994.	187.40	0.189	3 MAIN
15	6.80	1.450	76.32	24.05	4725.00	6495.00	6689.00	6348.	5.293	1020.	195.30	0.191	3 MAIN
16	6.10	1.450	81.40	24.10	5734.00	7882.00	8121.00	6915.	5.183	976.	190.70	0.195	3 MAIN
17	6.60	1.450	86.49	24.09	6878.00	9454.00	9744.00	7532.	5.056	1122.	224.50	0.200	3 MAIN
18	7.20	1.450	91.58	24.03	8165.00	11220.00	11570.00	8200.	4.917	1296.	266.40	0.206	3 MAIN
19	7.70	1.450	96.67	23.92	9603.00	13200.00	13610.00	8924.	4.769	1468.	309.80	0.212	3 MAIN
20	8.90	1.450	101.80	23.77	11200.00	15390.00	15890.00	9707.	4.615	1780.	389.30	0.219	3 MAIN
21	7.50	1.450	106.80	23.57	12970.00	17820.00	18400.00	10550.	4.458	1575.	356.40	0.226	3 MAIN
22	4.30	1.450	111.90	23.35	14910.00	20490.00	21170.00	11460.	4.299	946.	221.80	0.235	3 MAIN
23	1.50	1.450	117.00	23.10	17030.00	23410.00	24200.00	12440.	4.140	345.	83.97	0.243	3 MAIN
24	1.30	1.450	122.10	22.83	19350.00	26600.00	27510.00	13500.	3.983	312.	78.90	0.253	3 MAIN
25	0.70	1.450	127.20	22.53	21870.00	30070.00	31110.00	14630.	3.828	175.	46.03	0.263	3 MAIN
26	0.50	1.450	132.30	22.23	24610.00	33820.00	35010.00	15840.	3.676	130.	35.59	0.274	3 MAIN
27	0.40	1.450	137.40	21.91	27560.00	37880.00	39230.00	17140.	3.529	108.	30.79	0.285	3 MAIN
28	0.50	1.450	142.70	21.60	32130.00	44400.00	46050.00	19210.	3.265	140.	43.13	0.308	3 MAIN
29	0.50	1.450	150.10	21.25	37250.00	51750.00	53750.00	21530.	3.017	145.	48.31	0.333	3 MAIN
30	0.50	1.450	156.50	20.87	42950.00	60010.00	62410.00	24110.	2.787	150.	54.09	0.361	3 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.74	KNOTS
EFFECTIVE POWER	7336.	HP
SHAFT POWER....	10090.	HP
TURBINE POWER..	10420.	HP
TURBINE FUEL...	7526.	LBS/HR (0.213 TONS/MILE)
PROPULSION FUEL	7614.	LBS/HR (0.216 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	7.	KW
GENERATOR LUBE SYSTEM	3.	KW
HELIUM COMPRESSORS...	100.	KW
TOTAL LOAD..	110.	KW (87.6 LBS/HR)

THREE MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
3 MAIN	1.00	5.09	0.99	91.29	2236.46	1.4500	72.75	0.04	87.16	0.02	17.94	100.00	8.31	92.27	LF
3 MAIN	2.00	10.18	3.97	182.76	2333.94	1.4500	72.75	0.27	92.94	0.18	17.96	100.00	16.64	357.27	LF
3 MAIN	3.00	15.26	8.94	274.41	2459.00	1.4500	72.75	0.85	94.98	0.59	17.98	100.00	24.98	795.02	LF
3 MAIN	4.00	20.35	15.89	366.24	2612.64	1.4500	72.75	1.87	95.98	1.31	18.00	100.00	33.34	1405.51	LF
3 MAIN	5.00	25.44	24.83	458.26	2795.92	1.4500	72.75	3.40	96.56	2.39	18.01	100.00	41.71	2188.74	LF
3 MAIN	6.00	30.53	35.76	584.72	3008.71	1.4500	72.75	5.44	96.33	3.83	19.15	94.14	50.09	3144.71	LF
3 MAIN	7.00	35.61	48.67	721.11	3249.12	1.4500	72.75	7.99	96.98	5.64	20.25	89.15	58.48	4273.42	LF
3 MAIN	8.00	40.70	63.57	861.32	3518.08	1.4500	72.75	11.00	97.07	7.77	21.16	85.38	66.89	5574.88	
3 MAIN	9.00	45.79	80.46	1003.69	3816.98	1.4500	72.75	14.43	97.15	10.20	21.92	82.51	75.31	7049.07	
3 MAIN	10.00	50.88	99.33	1146.79	4147.48	1.4500	72.75	18.22	97.15	12.87	22.54	80.32	83.74	8696.01	
3 MAIN	11.00	55.97	120.18	1289.36	4511.48	1.4500	72.75	22.29	97.16	15.75	23.04	78.66	92.19	10515.69	
3 MAIN	12.00	61.05	143.03	1430.34	4911.11	1.4500	72.75	26.58	97.16	18.79	23.43	77.43	100.65	12508.11	
3 MAIN	13.00	66.14	167.86	1568.80	5348.71	1.4500	72.75	31.03	97.14	21.93	23.72	76.55	109.12	14673.26	
3 MAIN	14.00	71.23	194.68	1703.98	5826.80	1.4500	72.75	35.59	97.12	25.15	23.92	75.98	117.61	17011.17	
3 MAIN	15.00	76.32	223.48	1835.24	6348.07	1.4500	72.75	40.19	97.09	28.39	24.05	75.66	126.11	19521.83	
3 MAIN	16.00	81.40	254.27	1962.05	6915.36	1.4500	72.75	44.79	97.06	31.63	24.10	75.56	134.63	22205.21	
3 MAIN	17.00	86.49	287.05	2084.61	7531.70	1.4500	72.75	49.34	97.03	34.83	24.09	75.66	143.15	25061.31	
3 MAIN	18.00	91.58	321.82	2200.82	8200.23	1.4500	72.75	53.82	96.99	37.98	24.03	75.93	151.69	28090.16	
3 MAIN	19.00	96.67	358.57	2312.28	8924.23	1.4500	72.75	58.19	96.95	41.04	23.92	76.36	160.25	31291.80	
3 MAIN	20.00	101.76	397.30	2418.26	9707.07	1.4500	72.75	62.42	96.91	44.01	23.77	76.93	168.82	34666.17	
3 MAIN	21.00	106.84	438.03	2518.70	10552.27	1.4500	72.75	66.50	96.86	46.86	23.57	77.64	177.40	38213.25	
3 MAIN	22.00	111.93	480.74	2613.61	11463.42	1.4500	72.75	70.42	96.81	49.60	23.35	78.46	185.99	41933.10	
3 MAIN	23.00	117.02	525.43	2703.09	12444.13	1.4500	72.75	74.16	96.76	52.21	23.10	79.39	194.60	45825.68	
3 MAIN	24.00	122.11	572.12	2787.22	13498.28	1.4500	72.75	77.72	96.71	54.68	22.83	80.41	203.22	49890.99	
3 MAIN	25.00	127.19	620.79	2866.18	14629.54	1.4500	72.75	81.10	96.66	57.03	22.53	81.54	211.85	54129.05	
3 MAIN	26.00	132.28	671.44	2940.13	15841.82	1.4500	72.75	84.29	96.60	59.24	22.23	82.75	220.50	58539.85	
3 MAIN	27.00	137.37	724.09	3009.28	17138.99	1.4500	72.75	87.30	96.55	61.32	21.91	84.04	229.16	63123.40	
3 MAIN	28.00	142.46	778.73	3073.80	18525.91	1.4500	72.75	90.12	96.49	63.26	21.60	85.41	237.83	67880.75	
3 MAIN	29.00	147.54	835.36	3134.00	20006.55	1.4500	72.75	92.74	96.42	65.06	21.29	86.87	246.51	72812.00	
3 MAIN	30.00	152.63	893.98	3190.17	21584.97	1.4500	72.75	95.17	96.36	66.72	20.98	88.41	255.20	77917.25	
3 MAIN	31.00	157.72	954.59	3242.61	23265.36	1.4500	72.75	97.41	96.29	68.24	20.68	90.03	263.89	83196.50	
3 MAIN	32.00	162.81	1017.19	3291.61	25051.98	1.4500	72.75	99.46	96.22	69.62	20.38	91.72	272.59	88649.75	
3 MAIN	33.00	167.89	1081.78	3337.52	26949.19	1.4500	72.75	101.32	96.15	70.86	20.09	93.48	281.29	94277.00	
3 MAIN	34.00	172.98	1148.36	3380.66	28961.44	1.4500	72.75	102.98	96.08	71.96	19.80	95.31	290.00	100078.25	
3 MAIN	35.00	178.07	1216.93	3421.36	31093.28	1.4500	72.75	104.45	96.00	72.91	19.52	97.21	298.71	106053.50	
3 MAIN	36.00	183.16	1287.49	3459.96	33349.34	1.4500	72.75	105.72	95.92	73.71	19.24	99.18	307.42	112202.75	
3 MAIN	37.00	188.24	1360.04	3496.80	35734.39	1.4500	72.75	106.79	95.84	74.36	18.97	101.22	316.14	118526.00	
3 MAIN	38.00	193.33	1434.58	3532.21	38253.31	1.4500	72.75	107.66	95.76	74.86	18.70	103.32	324.86	125023.25	
3 MAIN	39.00	198.42	1511.11	3566.53	40911.11	1.4500	72.75	108.33	95.67	75.23	18.44	105.49	333.58	131694.50	
3 MAIN	40.00	203.50	1589.63	3600.10	43712.87	1.4500	72.75	108.80	95.58	75.46	18.18	107.72	342.31	138539.75	
3 MAIN	41.00	208.59	1670.14	3633.26	46663.82	1.4500	72.75	109.08	95.49	75.57	17.93	110.01	351.04	145559.00	
3 MAIN	42.00	213.68	1752.64	3666.36	49769.36	1.4500	72.75	109.17	95.40	75.58	17.68	112.36	359.77	152752.25	
3 MAIN	43.00	218.77	1837.13	3699.74	53035.05	1.4500	72.75	109.07	95.31	75.49	17.44	114.77	368.50	160119.50	
3 MAIN	44.00	223.85	1923.61	3733.75	56466.62	1.4500	72.75	108.80	95.21	75.32	17.20	117.24	377.24	167660.75	
3 MAIN	45.00	228.94	2012.08	3768.74	60069.98	1.4500	72.75	108.35	95.11	75.07	16.97	119.77	385.98	175376.00	
3 MAIN	46.00	234.03	2102.54	3805.05	63851.22	1.4500	72.75	107.74	95.01	74.74	16.74	122.36	394.72	183265.25	
3 MAIN	47.00	239.11	2194.99	3843.04	67816.62	1.4500	72.75	106.98	94.91	74.34	16.52	125.00	403.46	191328.50	
3 MAIN	48.00	244.20	2289.43	3883.07	71972.66	1.4500	72.75	106.08	94.80	73.88	16.30	127.70	412.21	199565.75	
3 MAIN	49.00	249.29	2385.86	3925.51	76326.04	1.4500	72.75	105.04	94.69	73.36	16.09	130.46	420.96	207977.00	
3 MAIN	50.00	254.38	2484.28	3970.74	80883.70	1.4500	72.75	103.87	94.58	72.79	15.88	133.28	429.71	216562.25	

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

REF.NO. 501- 5

THREE MAIN TURBINES

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
3 MAIN	1.00	5.09	0.99	1483.25	3300.00	1.4500	72.75	0.34	6.46	0.02	291.53	6.15	8.31	92.27	
3 MAIN	2.00	10.18	3.97	1476.00	3300.00	1.4500	72.75	0.50	35.29	0.13	145.05	12.38	16.64	357.27	
3 MAIN	3.00	15.26	8.94	1456.46	3300.00	1.4500	72.75	0.93	64.51	0.44	95.42	18.84	24.98	795.02	
3 MAIN	4.00	20.35	15.89	1417.07	3300.00	1.4500	72.75	1.76	81.07	1.04	69.63	25.85	33.34	1405.51	
3 MAIN	5.00	25.44	24.83	1346.87	3300.00	1.4500	72.75	3.11	89.37	2.02	52.95	34.02	41.71	2188.74	
3 MAIN	6.00	30.53	35.76	1223.33	3300.00	1.4500	72.75	5.13	93.72	3.50	40.07	45.00	50.09	3144.71	
3 MAIN	7.00	35.61	48.67	952.73	3300.00	1.4500	72.75	7.92	96.33	5.55	26.75	67.47	58.48	4273.42	
3 MAIN	8.00	40.70	63.57	861.32	3518.08	1.4500	72.75	11.00	97.07	7.77	21.16	85.33	66.86	5574.88	
3 MAIN	9.00	45.79	80.45	1003.69	3816.98	1.4500	72.75	14.43	97.13	10.20	21.92	82.91	75.31	7049.07	
3 MAIN	10.00	50.88	99.33	1146.79	4147.48	1.4500	72.75	18.22	97.16	12.87	22.54	80.32	83.74	8696.01	
3 MAIN	11.00	55.97	120.18	1289.36	4511.48	1.4500	72.75	22.29	97.16	15.75	23.04	78.66	92.19	10515.69	
3 MAIN	12.00	61.05	143.03	1430.34	4911.11	1.4500	72.75	26.58	97.16	18.79	23.43	77.43	100.65	12508.11	
3 MAIN	13.00	66.14	167.86	1568.80	5348.71	1.4500	72.75	31.03	97.14	21.93	23.72	76.55	109.12	14673.26	
3 MAIN	14.00	71.23	194.68	1703.98	5826.80	1.4500	72.75	35.59	97.12	25.15	23.92	75.98	117.61	17011.17	
3 MAIN	15.00	76.32	223.48	1835.24	6348.07	1.4500	72.75	40.19	97.09	28.39	24.05	75.66	126.11	19521.83	
3 MAIN	16.00	81.40	254.27	1962.05	6915.36	1.4500	72.75	44.79	97.06	31.63	24.10	75.56	134.63	22205.21	
3 MAIN	17.00	86.49	287.05	2084.01	7531.70	1.4500	72.75	49.34	97.03	34.83	24.09	75.66	143.15	25061.31	
3 MAIN	18.00	91.58	321.82	2200.82	8200.23	1.4500	72.75	53.82	96.99	37.98	24.03	75.93	151.69	28090.16	
3 MAIN	19.00	96.67	358.57	2312.28	8924.23	1.4500	72.75	58.19	96.95	41.04	23.92	76.36	160.25	31291.80	
3 MAIN	20.00	101.76	397.30	2418.26	9707.07	1.4500	72.75	62.42	96.91	44.01	23.77	76.93	168.82	34666.17	
3 MAIN	21.00	106.84	438.03	2518.70	10552.27	1.4500	72.75	66.50	96.86	46.86	23.57	77.64	177.40	38213.25	
3 MAIN	22.00	111.93	480.74	2613.61	11463.42	1.4500	72.75	70.42	96.81	49.60	23.35	78.46	185.99	41933.10	
3 MAIN	23.00	117.02	525.43	2703.09	12444.16	1.4500	72.75	74.16	96.76	52.21	23.10	79.39	194.60	45825.68	
3 MAIN	24.00	122.11	572.12	2787.22	13498.28	1.4500	72.75	77.72	96.71	54.68	22.83	80.41	203.22	49890.99	
3 MAIN	25.00	127.19	620.79	2866.18	14629.54	1.4500	72.75	81.10	96.66	57.03	22.53	81.54	211.85	54129.05	
3 MAIN	26.00	132.28	671.44	2940.13	15841.82	1.4500	72.75	84.29	96.60	59.24	22.23	82.75	220.50	58539.85	
3 MAIN	27.00	137.37	724.09	3009.28	17138.99	1.4500	72.75	87.30	96.55	61.32	21.91	84.04	229.16	63123.40	
3 MAIN	28.00	142.46	811.51	3102.80	19211.71	1.4500	72.36	91.42	96.42	63.79	21.60	85.41	240.05	70732.75	
3 MAIN	29.00	150.06	905.68	3188.44	21528.77	1.4500	71.97	95.22	96.29	65.99	21.25	86.97	251.10	78929.25	
3 MAIN	30.00	156.51	1006.86	3266.55	24113.38	1.4500	71.58	98.72	96.15	67.94	20.87	88.72	262.31	87734.25	
3 MAIN	31.00	163.03	1115.27	3337.52	26990.12	1.4500	71.19	101.92	96.00	69.65	20.47	90.63	273.68	97169.25	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

31 CARDS PRODUCED

ELECTRIC DRIVE SYSTEM

REF.NO. 501- 6

MISSION PROFILE SUMMARY - FOUR MAIN TURBINES

KTS	PCT. TIME	P/D RATIO	SHAFT RPM	SPEED RATIO	EFFECTIVE HP	SHAFT HP	TURBINE HP	FUEL RATE (PPH)	RANGE (NM/TON)	PER THOUSAND HOURS: NAUT. MILES	PER THOUSAND HOURS: TONS FUEL	TONS PER MILE	NO. OF TURBINES
1	1.10	1.450	5.09	291.60	1.40	1.92	39.06	4400.	0.509	11.	22.02	2.002	4 MAIN
2	1.20	1.450	10.18	145.30	11.20	15.39	52.97	4400.	1.018	24.	24.02	1.001	4 MAIN
3	1.20	1.450	15.26	95.88	37.80	51.96	90.01	4400.	1.527	36.	24.02	0.667	4 MAIN
4	1.20	1.450	20.35	70.48	89.60	123.20	161.60	4400.	2.036	48.	24.02	0.500	4 MAIN
5	1.20	1.450	25.44	54.39	175.00	240.50	279.00	4400.	2.545	60.	24.02	0.400	4 MAIN
6	1.20	1.450	30.53	42.58	302.40	415.70	453.70	4400.	3.055	72.	24.02	0.334	4 MAIN
7	1.20	1.450	35.61	32.44	480.20	660.10	696.70	4400.	3.564	84.	24.02	0.286	4 MAIN
8	1.20	1.450	40.70	18.65	716.80	985.30	1016.00	4425.	4.050	96.	24.15	0.252	4 MAIN
9	1.20	1.450	45.79	19.37	1021.00	1403.00	1445.00	4759.	4.236	108.	25.94	0.240	4 MAIN
10	1.20	1.450	50.88	19.98	1400.00	1924.00	1982.00	5126.	4.370	120.	27.91	0.233	4 MAIN
11	6.30	1.450	55.97	20.49	1863.00	2561.00	2637.00	5828.	4.458	693.	157.80	0.228	4 MAIN
12	6.70	1.450	61.05	20.90	2419.00	3325.00	3423.00	5966.	4.505	804.	181.00	0.225	4 MAIN
13	7.00	1.450	66.14	21.24	3076.00	4228.00	4352.00	6444.	4.519	910.	204.00	0.224	4 MAIN
14	7.10	1.450	71.23	21.49	3842.00	5280.00	5437.00	6963.	4.504	994.	223.40	0.225	4 MAIN
15	6.80	1.450	76.32	21.68	4725.00	6495.00	6688.00	7526.	4.464	1020.	231.10	0.227	4 MAIN
16	6.10	1.450	81.40	21.81	5734.00	7882.00	8118.00	8135.	4.405	976.	223.90	0.229	4 MAIN
17	6.60	1.450	86.49	21.89	6878.00	9454.00	9740.00	8794.	4.330	1122.	261.70	0.233	4 MAIN
18	7.20	1.450	91.58	21.91	8165.00	11220.00	11570.00	9504.	4.242	1236.	308.30	0.738	4 MAIN
19	7.70	1.450	96.67	21.89	9603.00	13200.00	13610.00	10270.	4.144	1403.	356.10	0.243	4 MAIN
20	8.90	1.450	101.80	21.93	11200.00	15390.00	15880.00	11090.	4.038	1780.	444.40	0.250	4 MAIN
21	7.50	1.450	106.80	21.73	12970.00	17820.00	18380.00	11980.	3.927	1575.	404.20	0.257	4 MAIN
22	4.30	1.450	111.90	21.60	14910.00	20490.00	21150.00	12930.	3.811	946.	250.00	0.264	4 MAIN
23	1.50	1.450	117.00	21.44	17030.00	23410.00	24170.00	13950.	3.693	345.	94.05	0.273	4 MAIN
24	1.30	1.450	122.10	21.26	19350.00	26600.00	27480.00	15040.	3.574	312.	87.86	0.282	4 MAIN
25	0.70	1.450	127.20	21.08	21870.00	30070.00	31070.00	16210.	3.455	175.	50.96	0.291	4 MAIN
26	0.50	1.450	132.30	20.84	24610.00	33820.00	34970.00	17460.	3.336	130.	39.19	0.301	4 MAIN
27	0.40	1.450	137.40	20.60	27560.00	37880.00	39180.00	18790.	3.219	108.	33.73	0.312	4 MAIN
28	0.30	1.450	143.70	20.40	32130.00	44400.00	45970.00	20900.	3.001	84.	28.14	0.335	4 MAIN
29	0.30	1.450	150.10	20.16	37250.00	51750.00	53650.00	23260.	2.793	87.	31.31	0.360	4 MAIN
30	0.30	1.450	156.50	19.98	42950.00	60010.00	62280.00	25880.	2.596	90.	34.83	0.387	4 MAIN
31	0.30	1.450	163.00	19.57	49290.00	69240.00	71960.00	28790.	2.412	93.	38.73	0.416	4 MAIN
32	0.30	1.450	169.60	19.24	56300.00	79520.00	82760.00	32020.	2.239	96.	43.06	0.449	4 MAIN

PERFORMANCE AVERAGES OVER MISSION PROFILE (1000 HOURS)

SPEED.....	15.76	KNOTS
EFFECTIVE POWER	7429.	HP
SHAFT POWER....	10230.	HP
TURBINE POWER..	10550.	HP
TURBINE FUEL...	8809.	LBS/HR (0.250 TONS/MILE)
PROPULSION FUEL	8897.	LBS/HR (0.252 TONS/MILE)

AVERAGE ELECTRICAL LOAD

PROPULSION COOLING...	7.	KW
GENERATOR LUBE SYSTEM	4.	KW
HELIUM COMPRESSORS...	100.	KW
TOTAL LOAD..	111.	KW (88.4 LBS/HR)

FOUR MAIN TURBINES

REF.NO. 501- 6

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
4 MAIN	1.00	5.09	0.99	91.28	2977.57	1.4500	72.75	0.03	85.25	0.02	17.94	100.00	8.31	92.27	LF
4 MAIN	2.00	10.18	3.97	182.72	3094.79	1.4500	72.75	0.21	91.33	0.14	17.96	100.00	16.64	357.27	LF
4 MAIN	3.00	15.26	8.94	274.33	3240.08	1.4500	72.75	0.65	94.20	0.44	17.97	100.00	24.96	795.02	LF
4 MAIN	4.00	20.35	15.89	366.10	3414.48	1.4500	72.75	1.44	95.39	1.00	17.99	100.00	33.34	1405.51	LF
4 MAIN	5.00	25.44	24.83	456.04	3619.05	1.4500	72.75	2.64	96.09	1.84	18.01	100.00	41.71	2188.74	LF
4 MAIN	6.00	30.53	35.76	550.14	3854.92	1.4500	72.75	4.26	96.53	2.99	18.02	100.00	50.09	3144.71	LF
4 MAIN	7.00	35.61	48.67	642.41	4123.28	1.4500	72.75	6.31	96.82	4.44	18.04	100.00	58.48	4273.42	LF
4 MAIN	8.00	40.70	63.57	759.05	4424.97	1.4500	72.75	8.76	96.97	6.18	18.05	96.81	66.89	5574.88	
4 MAIN	9.00	45.79	80.45	867.03	4758.72	1.4500	72.75	11.51	97.05	8.18	19.37	93.20	75.31	7049.07	
4 MAIN	10.00	50.88	99.33	1016.58	5125.73	1.4500	72.75	14.75	97.10	10.42	19.98	90.52	83.74	8696.01	
4 MAIN	11.00	55.97	120.18	1149.61	5527.58	1.4500	72.75	18.20	97.13	12.86	20.49	88.36	92.19	10515.69	
4 MAIN	12.00	61.05	143.03	1276.22	5966.48	1.4500	72.75	21.83	97.14	15.46	20.90	86.66	100.65	12508.11	
4 MAIN	13.00	66.14	167.86	1404.58	6444.25	1.4500	72.75	25.76	97.14	18.20	21.24	85.30	109.12	14673.36	
4 MAIN	14.00	71.23	194.68	1530.99	6963.32	1.4500	72.75	29.78	97.13	21.04	21.49	84.45	117.61	17011.17	
4 MAIN	15.00	76.32	223.48	1654.86	7526.13	1.4500	72.75	33.89	97.11	23.94	21.68	83.78	126.11	19521.83	
4 MAIN	16.00	81.40	254.27	1775.66	8135.34	1.4500	72.75	38.06	97.09	26.88	21.81	83.36	134.63	22205.21	
4 MAIN	17.00	86.49	287.05	1892.98	8793.72	1.4500	72.75	42.24	97.07	29.83	21.89	83.16	143.15	25061.31	
4 MAIN	18.00	91.58	321.82	2006.46	9504.23	1.4500	72.75	46.41	97.04	32.76	21.91	83.14	151.69	28090.16	
4 MAIN	19.00	96.67	358.57	2115.84	10269.91	1.4500	72.75	50.53	97.01	35.66	21.89	83.30	160.25	31291.80	
4 MAIN	20.00	101.76	397.30	2220.92	11093.96	1.4500	72.75	54.58	96.97	38.50	21.83	83.61	168.82	34666.17	
4 MAIN	21.00	106.84	438.03	2321.54	11979.66	1.4500	72.75	58.53	96.94	41.28	21.73	84.06	177.40	38213.25	
4 MAIN	22.00	111.93	480.74	2417.63	12930.45	1.4500	72.75	62.37	96.90	43.97	21.60	84.64	185.99	41933.10	
4 MAIN	23.00	117.02	525.43	2509.16	13949.79	1.4500	72.75	66.09	96.85	46.57	21.44	85.33	194.60	45825.68	
4 MAIN	24.00	122.11	572.12	2596.12	15041.30	1.4500	72.75	69.67	96.82	49.07	21.26	86.14	203.22	49890.99	
4 MAIN	25.00	127.19	620.79	2678.57	16208.59	1.4500	72.75	73.11	96.78	51.47	21.05	87.04	211.85	54129.05	
4 MAIN	26.00	132.28	671.44	2756.59	17455.42	1.4500	72.75	76.40	96.73	53.76	20.84	88.04	220.50	58539.85	
4 MAIN	27.00	137.37	724.09	2830.27	18785.59	1.4500	72.75	79.54	96.69	55.95	20.60	89.12	229.16	63123.40	
4 MAIN	28.00	142.46	811.51	2981.38	20903.02	1.4500	72.36	83.83	96.58	58.62	20.40	90.17	240.05	70732.75	
4 MAIN	29.00	150.06	905.66	3024.71	23761.31	1.4500	71.97	87.96	96.47	61.07	20.16	91.42	251.10	78929.25	
4 MAIN	30.00	156.51	1006.86	3111.26	25883.15	1.4500	71.58	91.78	96.35	63.30	19.98	92.86	262.31	87734.25	
4 MAIN	31.00	163.03	1115.27	3190.95	28792.72	1.4500	71.19	95.32	96.22	65.29	19.57	94.48	273.68	97169.25	
4 MAIN	32.00	169.62	1231.19	3264.05	32015.66	1.4500	70.80	98.59	96.09	67.07	19.24	96.28	285.21	107256.44	
4 MAIN	33.00	176.27	1354.85	3330.89	35578.89	1.4500	70.41	101.61	95.95	68.64	18.90	98.24	296.90	118017.31	HF

LF = FUEL BELOW MINIMUM REQUIRED RATE
HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

FOUR MAIN TURBINES

REF.NO. 501- 6

TURBINE CONFIG.	SPEED (KNOTS)	SHAFT RPM	SHFT TRQ (TH.LB-FT)	TURBINE RPM	FUEL RATE	P/D RATIO	PROP. EFF.	TURBINE FOM	DRIVE EFF.	TOTAL EFF.	SPEED RATIO	PERCENT FIELD	BUSS VOLTAGE	MOTOR AMPS	
4 MAIN	1.00	5.09	0.99	1483.51	4400.00	1.4500	72.75	0.34	4.93	0.01	291.58	6.15	8.31	92.27	
4 MAIN	2.00	10.18	3.97	1478.04	4400.00	1.4500	72.75	0.46	29.07	0.10	145.25	12.36	16.64	357.27	
4 MAIN	3.00	15.26	8.94	1463.48	4400.00	1.4500	72.75	0.78	57.72	0.33	95.88	18.74	24.98	795.02	
4 MAIN	4.00	20.35	15.89	1434.32	4400.00	1.4500	72.75	1.40	76.23	0.78	70.48	25.52	33.34	1405.51	
4 MAIN	5.00	25.44	24.83	1383.69	4400.00	1.4500	72.75	2.42	86.21	1.52	54.39	33.10	41.71	2188.74	
4 MAIN	6.00	30.53	35.76	1299.77	4400.00	1.4500	72.75	3.93	91.61	2.62	42.58	42.23	50.09	3144.71	
4 MAIN	7.00	35.61	48.67	1155.21	4400.00	1.4500	72.75	6.04	94.73	4.16	32.44	55.61	58.48	4273.42	
4 MAIN	8.00	40.70	63.57	759.05	4424.97	1.4500	72.75	8.76	96.97	6.18	18.65	96.81	66.89	5574.88	
4 MAIN	9.00	45.79	80.45	887.03	4758.72	1.4500	72.75	11.59	97.05	8.18	19.37	93.28	75.31	7049.07	
4 MAIN	10.00	50.88	99.33	1016.58	5125.73	1.4500	72.75	14.75	97.10	10.42	19.98	90.52	83.74	8696.01	
4 MAIN	11.00	55.97	120.18	1146.61	5527.68	1.4500	72.75	18.20	97.13	12.86	20.49	88.36	92.19	10515.69	
4 MAIN	12.00	61.05	143.03	1276.23	5966.48	1.4500	72.75	21.88	97.14	15.46	20.90	86.68	100.65	12508.11	
4 MAIN	13.00	66.14	167.86	1404.58	6444.26	1.4500	72.75	25.76	97.14	18.20	21.24	85.40	109.12	14673.26	
4 MAIN	14.00	71.23	194.68	1530.99	6963.32	1.4500	72.75	29.78	97.13	21.04	21.49	84.45	117.61	17011.17	
4 MAIN	15.00	76.32	223.48	1654.86	7526.13	1.4500	72.75	33.89	97.11	23.94	21.68	83.78	126.11	19521.83	
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HF = FUEL ABOVE MAXIMUM FUEL RATE
HS = TURBINE SPEED EXCESSIVE
HFS = TURBINE FUEL AND SPEED EXCESSIVE

33 CARDS PRODUCED

APPENDIX D

DESCRIPTION OF ENGINE ROOM MODIFICATIONS

Description of Engine Room Modifications for Installation of High Efficiency Propulsion Systems in Destroyer Type Hulls

Prepared for

Bradford Computer & Systems, Inc.

1700 Broadway

New York, New York 10019

Under Contract

N0014-74-C-0398

by

M. Rosenblatt & Sons, Inc.

350 Broadway

New York, New York 10013

BSDD-2870-05

CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF DRAWINGS

The following drawings, which are under separate cover, supplement this report.

MR&S DWG. NO.	TITLE
2870-01	Addition of 5000 HP Cruise Gas Turbine for DD's
2870-02	Addition of Crossover Alternator for DD's
2870-03	Superconducting Electric Propulsion for DD's, Existing Configuration
2870-04	Superconducting Electric Propulsion for DD's, Reconfigured Engine Room

1. Introduction

At the request of Bradford Computer and Systems, Inc. (15 July 1974, C-2870) M. Rosenblatt & Son, Inc. was to conduct a study, at a feasibility level, of modifying the propulsion system of a modern type destroyer in order to obtain a higher fuel efficiency during cruising and low speed operations.

Baseline information as to the system configuration for each modification was based on information furnished by Bradford. In those instances where information was not directly applicable to the propulsion systems under study, new definitions of equipment configuration were engineered or estimated. This work involved ascertaining equipment characteristics of possible candidate systems and investigating the feasibility of integrating each system into the configuration of a modern type destroyer.

In order to demonstrate the feasibility of adding new equipment to typical modern destroyer type ships, in conjunction with the study of the comparative performance of high efficiency ship propulsion systems, four arrangement drawings have been prepared. Each drawing shows the modifications to both forward and after engine rooms to accommodate the required equipment for each proposed propulsion system. The propulsion configuration of an existing destroyer type (DD963) was used as a baseline for the equipment arrangements in order to provide a real life basis for the study. The baseline propulsion system consists of four LM-2500 gas turbines (80,000 HP total), mechanically geared to two independent shafts (40,000 HP each) and is considered representative of modern destroyer type ships. The four possible modifications to this baseline system are summarized as follows:

1.1 Drawing No. 2870-01 shows the addition of two 5000 HP gas turbines, one to each engine room, to provide the capability for reduced power

cruising. Each new gas turbine is mechanically coupled to the existing main propulsion gear.

1.2 Drawing No.2870-02 shows the addition of a 10,000 HP alternator and its associated equipment to each engine room, to permit a single propulsion turbine to drive both shafts via an electrical crossover between port and starboard propulsion systems. During crossover operation, one alternator will be driven as a synchronous motor by the other alternator.

1.3 Drawing No.2870-03 shows the substitution of superconducting electric propulsion equipment for the existing mechanical reduction gearing, while retaining the existing machinery arrangement. This modification provides the main propulsion system with the capability of accepting connections to external 5000 HP cruise turbines and an electrical crossover connection, both of which provide for cruising at reduced power levels.

1.4 Drawing No.2870-04 shows the substitution of superconducting electric propulsion equipment for mechanical reduction gearing, as above, except that the existing machinery configuration has been optimized by elevating the propulsion gas turbines to reduce intake and exhaust ducting and by locating the propulsion motors aft to reduce shaft length.

2. General

All four engine room arrangement drawings show equipment currently under development. The arrangements shown are based on preliminary information and are, of course, subject to change as a result of future design developments and as additional information is made available. Engineering

judgement was often required in allowing for service access and interface requirements.

Of the four engine room arrangements outlined in the introduction, those showing the addition of high performance alternators and superconducting machinery have been based on data previously developed through prior propulsion studies primarily for a SWATH type ship, and additional information furnished by Bradford Computer and Systems, Inc.

Although there is a convenient similarity between the SWATH propulsion plant and that of the destroyer chosen as typical of modern destroyer types, (twin screw, 80,000 sub total), some modification of the SWATH propulsion plant was necessary for installation in the destroyer type hull. The SWATH was provided with a large single engine room containing both port and starboard propulsion plants. Many of the services for the superconducting machinery on both plants (i.e. helium, coolanol, etc.) had a common source.

Destroyers, on the other hand, are usually provided with two separate engine rooms, each intended to be as independent as is practical from the other. Thus, in the destroyer arrangement drawings, several of the SWATH systems have been modified to provide independent superconducting machinery support systems, such as helium and coolanol systems for each engine room, as shown in Figure 2-1. In addition, motor and generator bearing lube oil requirements have been provided from the existing main lube oil system, in lieu of providing each new machine with its own individual lube oil system, as was shown for the SWATH study.

D-6

Subject FLUID SYSTEMS, EACH ENGINE ROOM

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's

Section B-B-B-B Prepared by [illegible] Date 10/74 Checked Reviewed

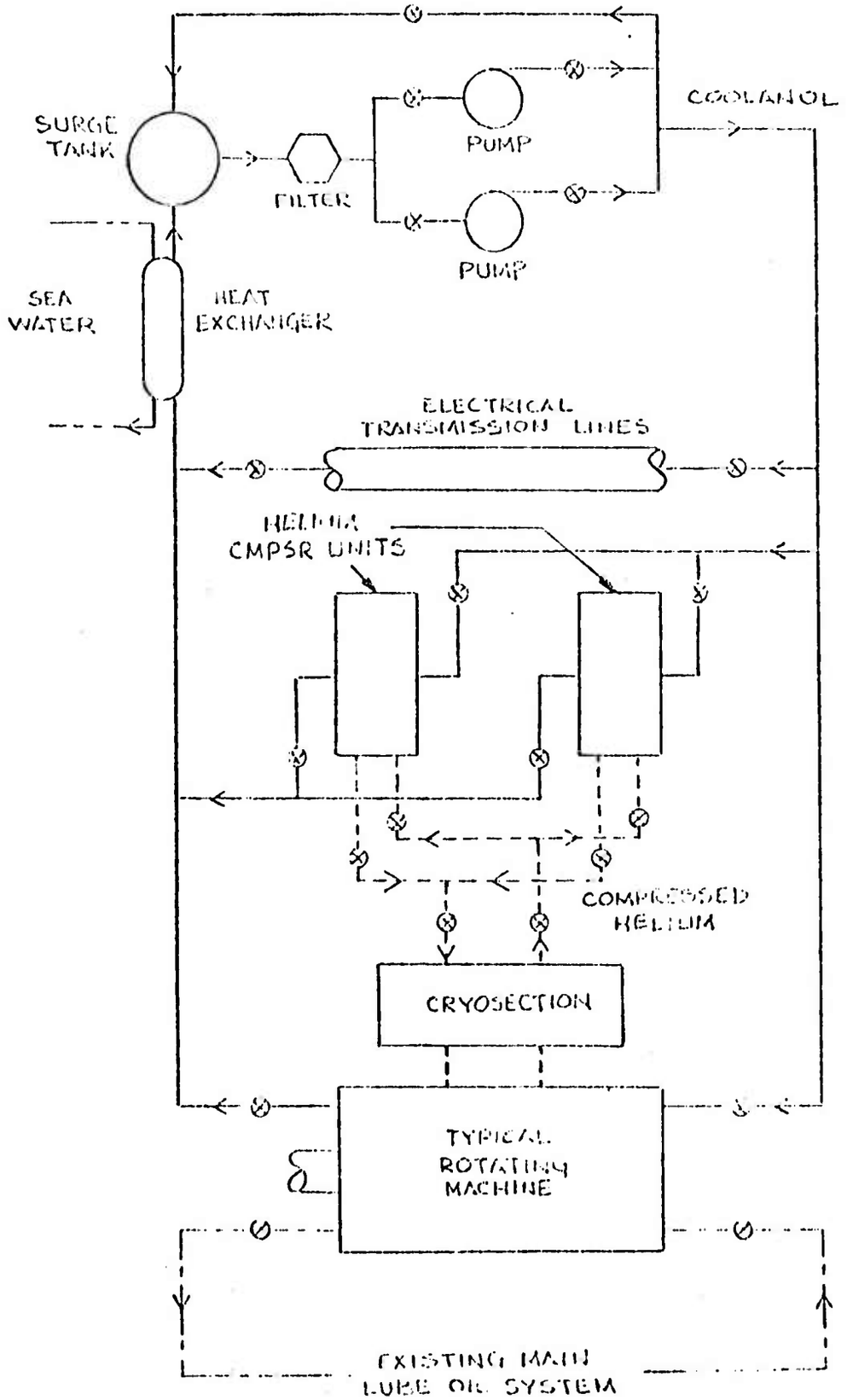

FIGURE 2-1 FLUID SYSTEMS SCHEMATIC DIAGRAM (EACH ENGINE ROOM)

3. Modifications

3.1 Addition of Cruise Turbines (Drawing No. 2870-01)

The cruise turbine size shown was based on available information for modern marine gas turbines of approximately 5000 HP. The space shown will accommodate the Garrett GTPF990 engine, currently under development for the U.S. Navy. The cruise turbine output is mechanically coupled through angle gearing to the existing main reduction gear which must be modified to accept the cruise turbine input shaft.

Other modifications necessary to accept the cruise turbine, its gearing and its ductwork are as follows:

a. The shaft turning gear was relocated to the opposite side of the reduction gear.

b. The main lube oil cooler was relocated to the 7'-6" level, alongside the main reduction gear.

c. Vertical ladders between the 24'-0" level and the 15'-0" level were relocated. In the forward engine room, this relocation placed the new vertical ladder close to the auxiliary boiler which normally would present a hazard to personnel. However, upgrading the boiler insulation in accordance with the recommendations of current Navy studies should eliminate any hazards due to heat from the boiler.

d. The machinery platform at the 15'-0" level was extended to provide a turbine and gear service aisle.

e. The auxiliary boiler exhaust duct was modified by the addition of a transition piece (from a circular to a

rectangular duct cross-section) to permit the new cruise turbine exhaust duct to be run under the existing boiler exhaust duct. In the aft engine room, the existing ship service generator intake duct was also re-routed to clear the new cruise turbine angle gearing.

f. Several power panels, lighting panels, starting air flasks (forward engine room), and fire-fighting cylinders and hose reels were relocated to suit the new arrangements and ductwork.

3.2 Addition of Crossover Alternators (Drawing No. 2870-02)

The alternator size shown, and the service requirements for this alternator were estimated from existing machine data and from data on other alternator sizes supplied by Bradford Computer and Systems, Inc. The data used in preparing this arrangement is summarized in Table 3-1. Transmission line cooling was not considered necessary as it was assumed that the alternator would be arranged to operate at a higher voltage rating than the acyclic machines used in the SWATH study and that output currents could be transmitted via normally installed Navy 5KVTSGA cable.

The alternator is mounted alongside the existing reduction gear and mechanically coupled via a new transfer gear and a modification to the existing reduction gear. Few other modifications to the existing engine room arrangement are required to accommodate the new equipment. These modifications consist mainly of relocating a few minor items (air starting flasks, fire fighting hose reels and cylinders, etc.) and modifying existing gratings as shown on the drawing.

M. Rosenblatt & Son, Inc. No. 2870

DESIGN CALCULATION SHEET Sheet 1 of 1

Subject 10,000 HP CROSSOVER ALTERNATOR

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD'S

Section BSDD Prepared by J.H. Springer Date 10/74 Checked Reviewed

TABLE 3-1 SUMMARY OF CHARACTERISTICS FOR 10,000 HP ALTERNATOR

1. ALTERNATOR SIZE AND WEIGHT: (APPROX.)

O.D.	3.0 FT
LENGTH	6.0 FT
VOLUME	40. CU FT
WEIGHT	11,000 LBS
SPEED, AT FULL POWER	5,000 RPM

2. ESTIMATED LOSSES TO COOLANT: 149 KW

WITH COOLANT - SEA WATER TEMPERATURES AND PRESSURES AS SHOWN IN "SWATH" STUDY:

COOLANT FLOW = 63 GPM
SEA WATER FLOW = 66 GPM

COOLANT PUMP LOAD = 2 HP

HEAT EXCHANGER SIZE (APPROX) =
9" DIA × 100" LENGTH, 350 LBS.

3.3 Substitution of Superconducting Electric Propulsion, Existing Engine Room Configuration (Drawing No. 2870-03)

In this configuration a superconducting electric propulsion system similar to that planned for the SWATH is substituted for the existing main reduction gear in each engine room. One 20,000 HP propulsion generator is direct coupled to each propulsion gas turbine and one 40,000 HP propulsion motor is direct coupled to each propulsion shaft.

The controllable pitch propeller (CRP) is locked into a fixed position and the CRP hydraulic system is removed. Alternately, the CRP could be replaced by a fixed pitch propeller, however the change in efficiency is considered to be small. The difference in weight between the CRP and a fixed pitch propeller was not estimated.

The existing reduction gear lube oil system is retained to provide bearing lube oil to the new equipment. The existing gear driven lube oil pump is replaced by an additional motor driven lube oil pump. The existing main lube oil cooler is retained and relocated to the 7'-6" level to provide space for the new coolanol system. The existing thrust bearing is replaced by a new pedestal type thrust bearing at the after bulkhead in each engine room.

The new helium and coolanol systems are installed mostly on the 15'-0" level which has been extended into the space formerly occupied by the main reduction gear. A new uninterrupted power supply (UPS) power panel and automatic bus transfer switch (ABT) are also installed on the 15'-0" level. Generator disconnect and

crossover switches are located at the 24'-0" level except for the forward engine room, where the crossover switch is located at the 15'-0" level.

With the exception of the air starting flasks in the forward engine room, almost no other modifications are required to the existing engine room equipment.

The 5000 HP cruise turbine, if used, can be modularized as shown in Figure 3.1 and installed on top of the deck house adjacent to the machinery casing as shown in Figure 3.2. Electrical transmission lines and service piping will be run within the machinery casing between the cruise turbine module and the engine room with disconnect devices in the engine room in the event of damage to the module. Separate disconnect devices are also provided in each engine room to isolate the electrical cross-connect between engine rooms in the event of damage. It should be noted that the cruise turbine module can be easily installed within a standard 8'x8'x20' shipping container.

3.4 Substitution of Superconducting Electric Propulsion, Reconfigured Engine Room (Drawing No. 2870-04)

This modification requires that the existing main reduction gear be replaced by superconducting electric propulsion, as does the previous modification. However, in this case an attempt is made to optimize the engine room arrangement by raising the main propulsion turbines and by relocating the main propulsion motors aft into the shaft alley area.

In this arrangement the propulsion gas turbines and the

Subject .5000 HP CRUISE TURBINE MODULE

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's

Section PSPD Prepared by [illegible] Date 10/74 Checked Reviewed

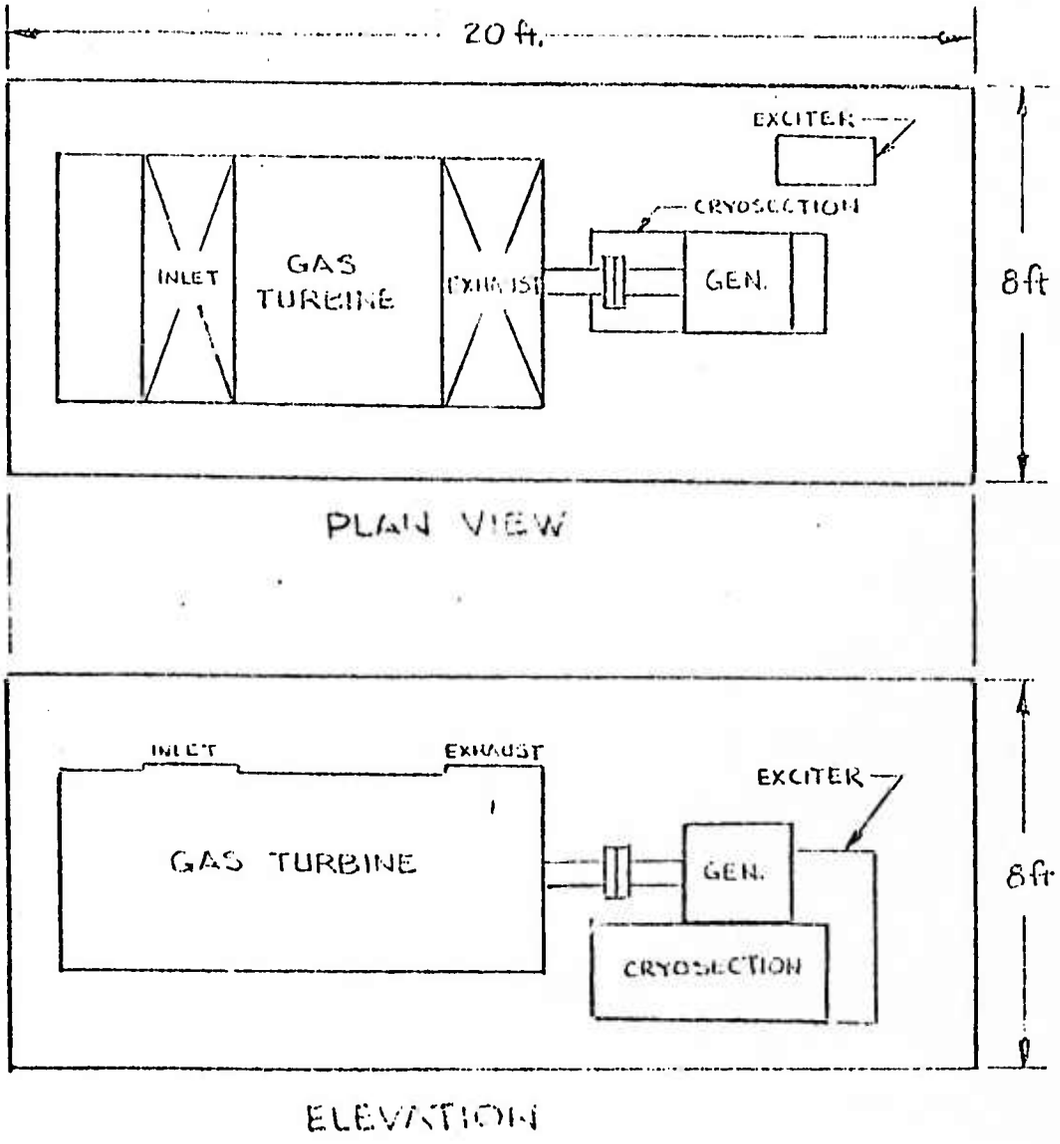

FIGURE 3-1

Subject LOCATION OF CRUISE TURBINE MODULES

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's

Section BSDD Prepared by [illegible] Date 10/74 Checked Reviewed

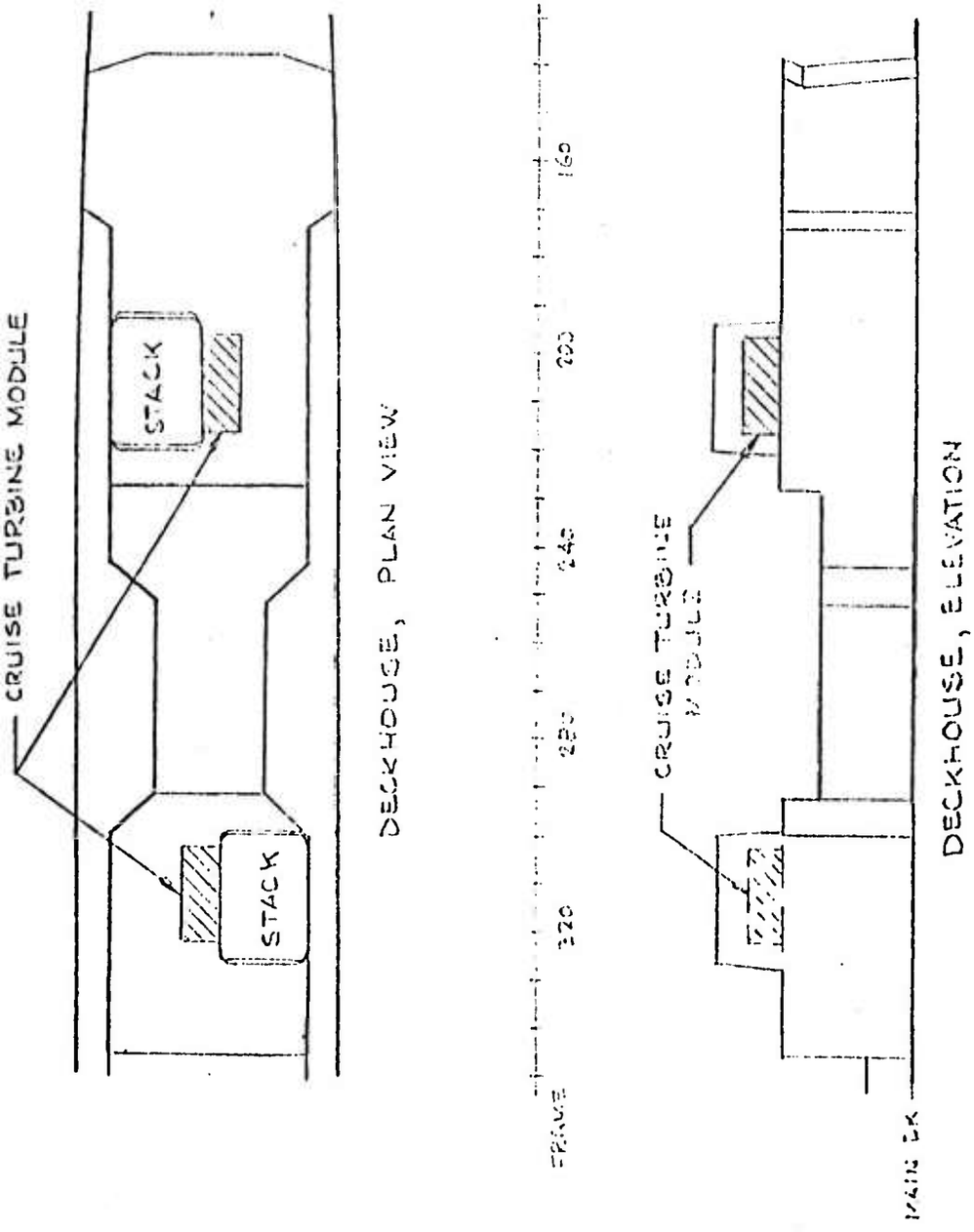

FIGURE 3-2

20,000 HP propulsion generators are moved up onto the 24'-0" level. In addition, the 24'-0" level is extended from the centerline to the shell to fill in the area formerly occupied by the gas turbine ductwork. The generator cryosections are located in the overhead of the 15'-0" level, directly under the propulsion generators.

The 15'-0" level is also extended from the centerline area to the shell. The helium and coolanol systems and the 20,000 HP generator disconnect switches are located on this level. The CRP system is locked in a fixed position as in the last arrangement (Section 3.3) and the existing attached lube oil pump is replaced by a new electrically driven lube oil pump. The main lube oil cooler is relocated to the 7'-6" level.

In this arrangement the existing lube oil storage and settling tanks are relocated from the 24'-0" level to the 15'0" level while the electronics cabinets on the 15'-0" level are moved to the 24'-0" level. This is to provide the inboard propulsion gas turbine on the 24'-0" level with a service access aisle. Several power panels, the fuel oil service heaters (aft engine room) and an air filter (forward engine room) were also relocated as part of this change.

With the 15'-0" level extended from the centerline area to the shell, there is no longer a need for two vertical access ladders and one of the ladders is eliminated in each engine room. It was necessary to relocate various fire fighting hose reels and cylinders, air starting cylinders (forward engine room) and vertical ladders from the 15'-0" level to the 7'6" level (forward engine room) and from the 15' -0" level to the 7' -6" level (forward engine room).

The location of the 5000 HP cruise turbines is as shown in Figure 3.2. Only one crossover switch is provided in the aft engine room, since both electric transmission lines must pass through this space.

The location of the propulsion motors is shown in Figure 3.3. The propulsion motors, in this location, appear to displace the shaft alley sewage treatment plant. However, the displaced equipment can be relocated to the space gained under the main propulsion turbines in one of the engine rooms. No attempt has been made at this time to optimize the shaft angles or relocate the shaft tubes. Additional studies are required into the serviceability of the propulsion motors in the location shown and into the possibility of providing a third set of helium-coolanol-lube oil service equipment in lieu of piping these services aft from the engine rooms.

4. Estimate of Weight Changes

Tables 4-1, 4-2, 4-3 lists the equipment removed and added as a result of the modifications in Section 3 and the estimated weights for the various equipment. In many cases, weights and sizes shown have been estimated from available information on equipment, that is currently under development. Due to the preliminary nature of much of the available information, no attempt was made to estimate changes in structural weights or changes in various ship systems caused by these modifications.

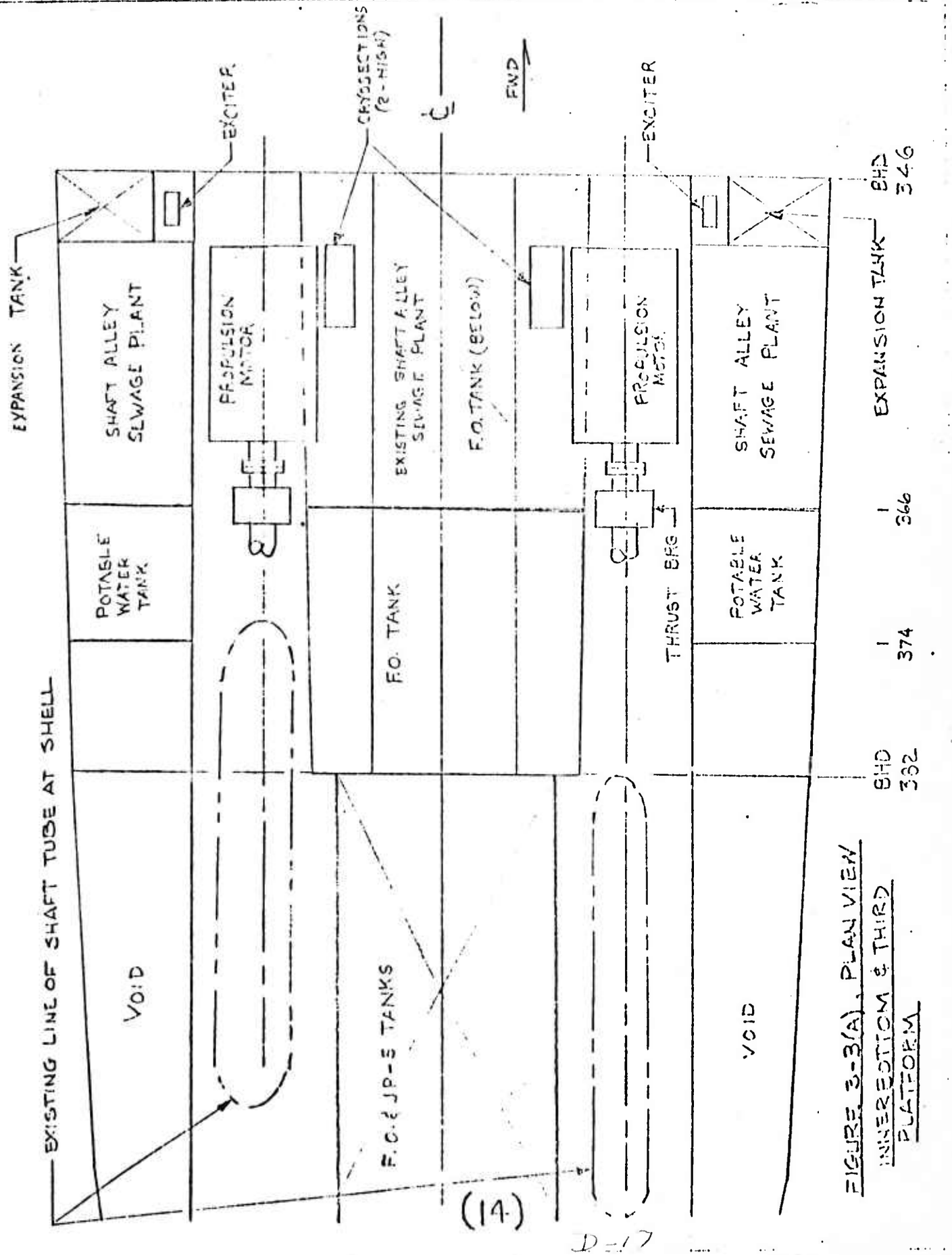

FIGURE 3-3(A). PLAN VIEW
INNERBOTTOM & THIRD PLATFORM

Subject LOCATION OF PROPULSION MOTORS

Ship or Project STUDY OF HIGH EFFICIENCY PROPULSION SYSTEMS FOR DD's

Section BSDD Prepared by J. P. Date 10/74 Checked Reviewed

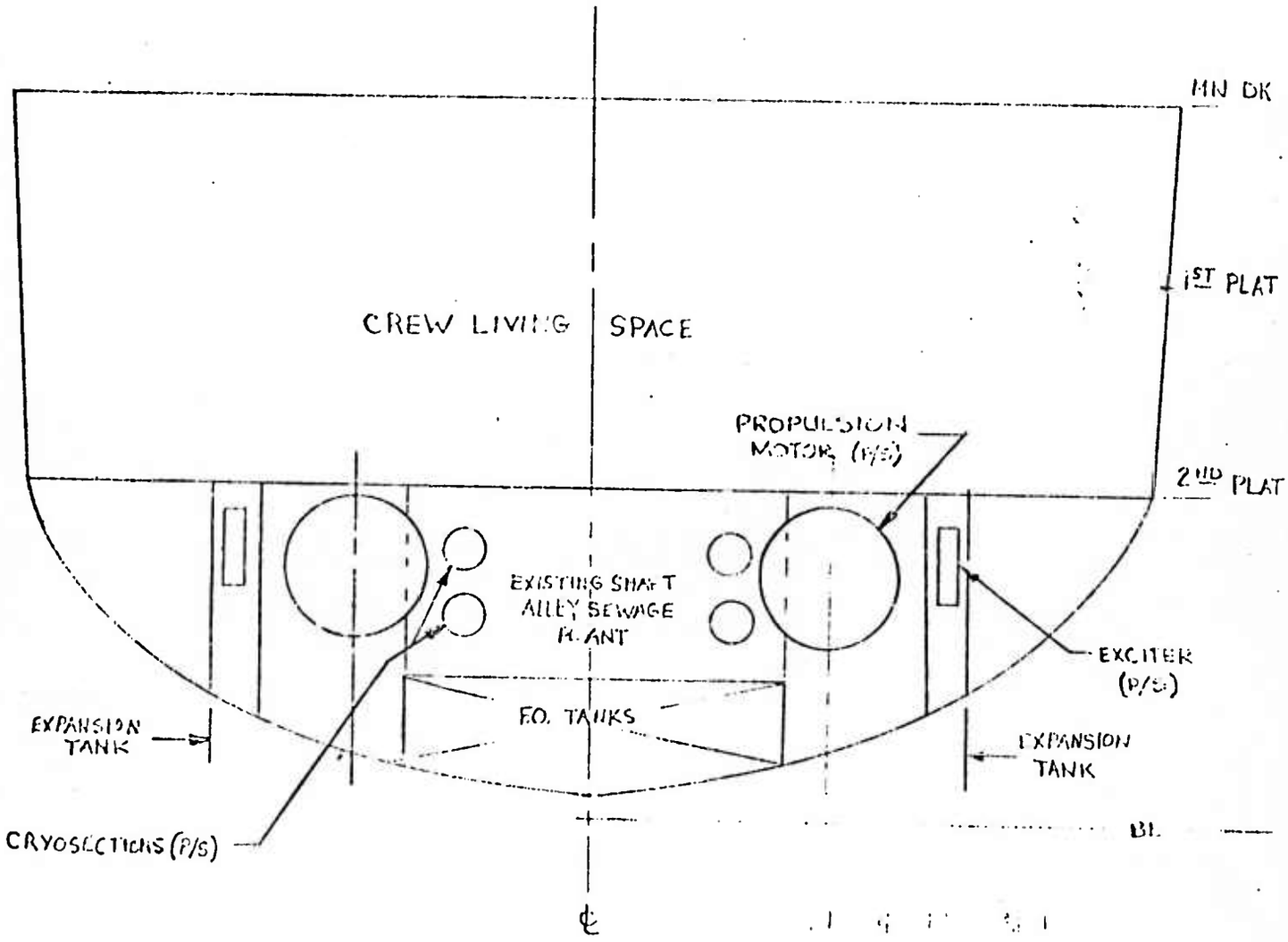

FIGURE 3-3 (B)

ELEVATION, FR 346, LOOKING AFT

TABLE 4 -1

SUMMARY OF WEIGHT CHANGES

ADDITION OF CRUISE TURBINE

LINE		QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT
1.	5,000 hp Gas Turbine	2	5,000	4'x5'x10'	10,000 lbs
2.	Transfer Gear & Clutch	2	6,000	4'x4'x4' &5'x5'x4.5'	12,000
		TOTAL			22,000 lbs

NOTES

1. Above quantities include equipment for both forward and aft engine rooms.

2. There is no equipment removed as a result of this modification.

3. Additional omitted weights:

   a. Modification to main reduction gear
   b. Ductwork and new service piping and cables for new cruise turbine

TABLE 4 - 2

SUMMARY OF WEIGHT CHANGES

ADDITION OF CROSSOVER ALTERNATOR

LINE		QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT
1.	10,000 hp Alternator	2	11,000	3' D x 6'	22,000 lbs
2.	Transfer Gear	2	12,000	8'x6'x3'	24,000
3.	Service Module	2	1,500		3,000
		TOTAL			49,000 lbs

NOTES

1. Above quantities include equipment for both forward and aft engine rooms.

2. There is no equipment removed as a result of this modification.

3. Weight added as a result of modification to existing main reduction gear is omitted.

TABLE 4 - 3

SUMMARY OF WEIGHT CHANGES

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE NOS.	ITEM	WEIGHT CHANGE IN LBS.
1 - 10	Fwd and Aft Engine Rooms - Weights Removed	(390,000)
11 - 37	Aft Engine Room - Weights Added	223,023
38 - 64	Fwd Engine Room - Weights Added	224,664
65	Crossover Between Engine Rooms - Weights Added	9,360
	TOTAL CHANGE IN WEIGHT	67,047

NOTES

1. Quantities for equipment removed includes equipment in both forward and aft engine rooms.

2. Weights for CRP hydraulic and Coolanol Systems considered to be even exchange except for new coolanol heat exchanges.

3. Additional study is required to confirm whether or not the high impedance element (25,000 lbs.) is required.

TABLE 4 - 3.1

FWD & AFT ENGINE ROOM WEIGHTS REMOVED

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
1.	Main Reduction Gear	2	170,000		340,000
2.	High Impedance Element (See Note 3)	2	35,000		50,000
3.	Attached Mn L.O. Pump	(Included in line 1)			
4.	" CRP Hyd Pump	"	"	"	"
5.	" Oil Dist. Box	"	"	"	"
6.	" Shaft Turn Gear	"	"	"	"
7.	Control -Shaft Turn Gear	(Misc.)			
8.	CRP Head Tank	(See Note 2)			
9.	CRP Sump Tank	"	"	"	
10.	CRP Hydr. Module	"	"	"	
		TOTAL REMOVED			(390,000)

TABLE 4 - 3.1

AFT ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
11.	Coolanol Pump (20hp)	2	(See Note 2)		
12.	Cont -Coolanol Pump	2	" " "		
13.	Coolanol Surge Tank	1	" " "		
14.	Coolanol Filter	1	" " "		
15.	Coolanol Heat Exchanger	1	4,000	1.5' Dx12'	4,000
16.	Thrust Bearing	1	12,000	3.8' Dx4'	12,000
17.	L.O. SVC Pump (50hp)	1	1,000		1,000
18.	Cont -L.O. SVC Pump (2 spd)	1	90		90
19.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
20.	Power Panel	1	380	2'x1'x3.5'	380
21.	Uninterrupted Power Supply	1	1,275	2.7'x2'x3'	1,275
22.	Propulsion Motor (40 K hp)	1	136,500	6.5' Dx11.7'	136,500
23.	Propulsion Generators (70 K hp)	2	10,500	3.2' Dx4.2'	21,000
24.	Exciters	3	375	1'x2'x3.5'	1,125
25.	Gen. Polarity & Discon.	2	5,100	3.7'x4'x5.8'	10,200
26.	Transmission Lines:				
27.	Generator				2,027
28.	Motor				3,008
29.	Helium Compressors	2	3,250	2.6' Dx7.8'	6,500
30.	Cryosections	4	933	2.0' Dx5'	3,732
31.	Cryolines				243
		SUB-TOTAL			203,430
32.	Crossover Switch	1	1,300	2'x2.7'x3.8'	1,300
33.	Transmission Line				1,584
		SUB-TOTAL			2,884

TABLE 4 - 3.1

AFT ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
34.	Cruise Turbine Module			8'x8'x20'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator		3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
35.	Transmission Line				1,813
36.	Cryoline				138
37.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2.5'x3.5'	1,100
		SUB-TOTAL			16,709
		TOTAL, AFT ENGINE ROOM			223,023

TABLE 4 - 3.2

FWD ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
38.	Coolanol Pump (20hp)	2	(See Note 2)		
39.	Cont -Coolanol Pump	2	" " "		
40.	Coolanol Surge Tank	1	" " "		
41.	Coolanol Filter	1	" " "		
42.	Coolanol Heat Exchanger	1	4,000	1.5' Dx12'	4,000
43.	Thrust Bearing	1	12,000	3.8' Dx4'	12,000
44.	L.O. SVC Pump (50 hp)	1	1,000		1,000
45.	Cont -L.O. SVC Pump (2 spd)	1	90		90
46.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
47.	Power Panel	1	380	2'x1'x3.5'	380
48.	Uninterrupted Power Supply	1	1,275	2.7'x2'x5'	1,275
49.	Propulsion Motor (40 K hp)	1	136,500	6.5' Dx11.7'	136,500
50.	Propulsion Generators (70 K hp)	2	10,500	3.2' Dx4.2'	21,000
51.	Exciters	3	375	1'x2'x3.5'	1,125
52.	Gen. Polarity & Discon.	2	5,100	3.7'x4'x5.8'	10,200
53.	Transmission Lines;				
54.	Generator				2,152
55.	Motor				3,008
56.	Helium Compressors	2	3,250	2.6' Dx7.8'	6,500
57.	Cryosections	4	933	2.0' Dx5'	3,732
58.	Cryolines				232
		SUB-TOTAL			203,444
59.	Crossover Switch	1	1,300	2'x2.7'x3.8'	1,300
60.	Transmission Line				360
		SUB-TOTAL			1,660

TABLE 4 - 3.2

FWD ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
61.	Cruise Turbine Module			8'x8'x20'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator	1	3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
62.	Transmission Line				4,018
63.	Cryoline				184
64.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2.5'x3.5'	1,100
		SUB-TOTAL			18,960
		TOTAL, FWD ENGINE ROOM			224,064

TABLE 4 - 3.3

SUPERCONDUCTING ELECTRIC PROPULSION
-EXISTING ENGINE ROOM CONFIGURATION

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
65.	Transmission Line				9,360
		TOTAL			9,360

TABLE 4 - 4

SUMMARY OF WEIGHT CHANGES

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

ITEM NOS.	LOCATION	WEIGHT CHANGE IN LBS.
1 - 11	Fwd and Aft Engine Rooms - Weights Removed	(538,200)
12 - 39	Aft Engine Room - Weights Added	74,620
40 - 58	Fwd Engine Room - Weights Added	86,667
59 - 62	Propulsion Motor Space - Weights Added	301,482
	TOTAL CHANGE IN WEIGHT	(75,431)

NOTES

1. Quantities for equipment removed included equipment in both forward and aft engine rooms.

2. Weights for CRP hydraulic and Coolanol Systems considered to be even exchange except for new coolanol heat exchanges.

3. Additional study is required to confirm that high impedance element can be removed.

TABLE 4 - 4.1

FWD & AFT ENGINE ROOM WEIGHTS REMOVED

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
1.	Main Reduction Gear	2	170,000		340,000
2.	High Impedance Element (See Note 3)	2	25,000		50,000
3.	Attached Mn L.O. Pump	(Included in line 1)			
4.	CRP Hyd Pump	"	"	"	"
5.	Oil Dist. Box	"	"	"	"
6.	Shaft Turn Gear	"	"	"	"
7.	Control -Shaft Turn Gear	(Misc.)			
8.	CRP Head Tank	(See Note 2)			
9.	CRP Sump Tank	"	"	"	
10.	CRP Hydr. Module	"	"	"	
11.	Main Propulsion Shafting	650 lb/ft		228'x18"	148,200
					538,200

D-28

TABLE 4 - 4.2

AFT ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
12.	Coolanol Pump (80 hp)	2	(See Note 2)		
13.	ContCoolanol Pump	2	(See Note 2)		
14.	Coolanol Surge Tank	1	(See Note 2)		
15.	Coolanol Filter	1	(See Note 2)		
16.	Coolanol Heat Exchanger	1	4,000	1.5' Dx12'	4,000
17.	(Not used)				
18.	L.O. SVC Pump (50 hp)	1	1,000		1,000
19.	Cont -L.O. SVC Pump (2SPO)	1	90		90
20	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
21.	Power Panel	1	380	2'x1'x3.5'	380
22.	Uninterrupted Power Supply	1	1,275	2.7'x2'x5'	1,275
23.	(Not used)				
24.	Propulsion Generators (70K hp)	2	10,500	3.2' Dx4.2'	21,000
25.	Exciters	2	375	1'x2'x3.5'	375
26.	Gen. Polarity & Discon	2	5,100	3.7'x4'x5.8'	10,200
27.	Transmission Lines:				
28.	Generator				3,126
29.	Motor				1,892
30.	(Not used)				
31.	Helium Compressors	2	3,250	2.8' Cx7'	6,500
32.	Cryosections	2	933	2.0' Dx5'	1,866
33.	Cryolines				322
			SUBTOTAL		52,751

TABLE 4 - 4.2

AFT ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
34.	Crossover Switch	1	1,300	2'x2.7'x3.8'	1,300
35.	Transmission Line				3,034
		SUBTOTAL			4,334
36.	Cruise Turbine Module			8.x8.x10'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator	1	3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
37.	Transmission Line				2,627
38.	Cryoline				150
39.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2.5'x3.5'	1,100
		SUB-TOTAL			17,535
		TOTAL, AFT ENGINE ROOM			74,620

TABLE 4 - 4.3

FWD ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
40.	Coolanol Pump (20 hp)	2	(See Note 2)		
41.	Cont - Coolanol Pump	2	" " "		
42.	Coolanol Surge Tank	1	" " "		
43.	Coolanol Filter	1	" " "		
44.	Coolanol Heat Exchanger	1	2,000	1.5' Dx12'	4,000
45.	L.O. SVC Pump (50 hp)	1	1,000		1,000
46	Cont -L.O. SVC Pump (2 spd)	1	90		90
47.	Auto Bus Transfer SW	1	350	0.8'x2'x3'	350
48.	Power Panel	1	380	2'x1'x3.5'	380
49.	Uninterrupted Power Supply	1	1,275	2.7'x2'x5'	1,275
50.	Propulsion Generators (70 K hp)	2	10,500	3.2' Cx4.2'	21,000
51.	Exciters	2	375	1'x2'x3.5'	750
52.	Gen. Polarity & Discon. SW	2	5,100	3.7'x4'x5.8'	10,200
53.	Transmission Lines:				
54.	Generator				2,469
55.	Motor				16,104
56.	Helium Compressors	2	3,250	2.8' Dx5'	6,500
57.	Cryosections	2	933	2.0' Dx5'	1,866
58.	Cryolines				752
			SUB-TOTAL		66,736

D-31

TABLE 4 - 4.3

FWD ENGINE ROOM WEIGHTS ADDED

SUPERCONDUCTING ELECTRIC PROPULSION
-RECONFIGURED ENGINE ROOM

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
59	Cruise Turbine Module			8x8x10'	
a.	5,000 hp Gas Turbine	1	5,000		5,000
b.	5,000 hp Generator	1	3,850		3,850
c.	Cryosection	1	933		933
d.	Exciter	1	375		375
e.	Container Structure	1	3,500		3,500
60.	Transmission Line				4,998
61.	Cryoline				175
62.	Gen. Polarity & Disconnect Switch	1	1,100	2'x2 5'x3.5'	1,100
		SUB-TOTAL			19,931
		TOTAL, FWD ENGINE ROOM			86,667

TABLE 4 - 4.4

PROPULSION MOTOR SPACE WEIGHTS ADDED

LINE	ITEM	QTY	UNIT WT (LBS)	UNIT SIZE	TOTAL WEIGHT (LBS)
63.	Propulsion Motors	2	136,500	6.5' Dx11.7'	273,000
64.	Thrust Bearings	2	12,000	3.8' Dx4'	24,000
65.	Exciters	2	375	1'x2'x3.5'	750
66	Cryosections	4	933	2' Dx5'	3,732
					301,482